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I.—A Revision of the North American Species of Frullania, a Genus of Hepaticæ. By Alexander W. Evans.

With the single exception of *Jungermannia* itself, as defined by most recent writers, the genus *Frullania* is the richest in species of all our hepatic genera, and the plants belonging to it are so distinct in their appearance and in their mode of life that the genus is one of the earliest which students of the liverworts learn to recognize. All of our species attain their best development in rather exposed localities, some of them on the trunks and branches of trees and bushes, others on rocks; and, unless we see them soon after a shower or on a moist, cool day, they appear quite shriveled up and lifeless. At such times the plants are dark red or brownish-green in color, most of them adhere closely to bark or rock, and their stems, toward their extremities, look like fine, radiating, branched lines with roundish irregularities produced by the leaves; in *Frullania squarrosa* the dry leaves are appressed to the stems and give them a somewhat worm-like appearance. As soon as the plants absorb water, they become strikingly different; their stems and leaves are no longer shrunken and brittle, but are turgid and flexible, and their colors are more lively and distinct. Several of our species are not absolutely restricted to exposed situations but are able to exist in more sheltered places; we find them, for example, on damp, shaded rocks, on rotten logs, or creeping over or through tufts of mosses. Such plants are rarely satisfactory for study, their leaves are more scattered than is normal, they reproduce almost entirely by vegetative means, and they often fail to develop the water-sacs which are so characteristic of our genus.

As in nearly all large and natural genera, the species of *Frullania* are difficult to define. Many of them are widely distributed and extremely variable, and the confusion to which these conditions naturally give rise has been increased by the tendency among older writers of magnifying slight or temporary differences between plants into specific characters and, at the same time, of disregarding more important points of distinction. In the Synopsis Hepaticarum of Gottsche, Lindenberg and Nees von Esenbeck (published from 1844 to 1847), twelve species are accredited to us; four of these are synonyms of the common *F. Eboracensis*, leaving us, therefore, only eight good species. During the forty years following the publication

of this work, new North American species were described from time to time, mainly by Austin, until, in 1884, Professor Underwood[1] was able to ascribe to our region twenty species of the genus. Of these twenty species, however, three are synonyms and two of the others, *F. Pennsylvanica* and *F. Hutchinsiæ*, var. (in reality the same plant[2]), have been transferred to the closely allied genus *Jubula*. This leaves sixteen species known at that time, including *F. inflata*, which is omitted in Professor Underwood's paper. The few new species which have been added since 1884 and the few described in the present paper, increase the number to twenty-two, of which several are still known to us only from scanty or incomplete material.

The generic characters of *Frullania* are so well stated in accessible literature, particularly in the writings of Spruce[3] and of Schiffner[4], that it would be superfluous to detail them here. The remarks which follow are simply to call attention to certain interesting peculiarities in leaf and perianth and to make clearer the specific descriptions given later on.

The leaves of *Frullania* are unequally complicate-bilobed, and the antical or "dorsal" lobe, which is called simply the "lobe," is larger than the other, spreads obliquely from the stem and is more or less orbicular in shape. In most cases, one side of this lobe arches over the stem and is often produced at the base into a cordate or auriculate expansion; the other side passes by a short and abrupt fold (except in *F. arietina*) into the postical or "ventral" lobe of the leaf. This lobe, in turn, is deeply divided, usually to the very base, into two unequal segments. The outer segment or "lobule" is the so-called "auricle" of older writers; it is an extremely variable organ, but, in all of our species, is normally hooded over and inflated, sometimes throughout its whole extent, into a galeate or clavate structure, which serves as a sac or reservoir for the temporary retention of water.[5] The inner segment or "stylus" is usually much smaller than the lobule and is reduced in some cases to a minute, subulate process consisting of only three or four cells; in *F. Asagrayana*, however, and in a few species allied to it, the stylus is larger and forms a disc-like cellular plate of considerable size. In *F. Caroli-*

[1] Bull. Illinois State Lab. Nat. Hist., ii: 61–68. 1884.

[2] Cf. Underwood, Bull. Torrey Bot. Club, xix: 301. 1892.

[3] Hep. Amaz. et And., 3. 1884.

[4] Engler and Prantl, Die natürlichen Pflanzenfamilien, Lief. 112: 132. 1895.

[5] Goebel, Ann. du Jard. Bot. de Buitenzorg, vii: 21. 1888.

niana and in one or two others, the first leaf of a branch sometimes develops both lobe and lobule into water-sacs; such a leaf is always quite covered over by other leaves.

It has already been noted that in sheltered places some species of *Frullania* may fail to develop water-sacs; the lobule under these circumstances is explanate and appears as a small, lanceolate, plane or slightly concave process; transitional forms may frequently be found between these explanate lobules and the typical inflated ones. In every species, however, there are three leaf-modifications where explanate lobules normally occur. These are (1) the leaves from whose axils branches spring, (2) the perichætial bracts, and (3) the perigonial bracts. In the first of these, the stylus is about as large as the lobule and the whole postical lobe is very like an underleaf; occasionally the modified stylus bears a small tooth or secondary stylus on its inner edge. Even in this situation, although the stylus always retains its modified form, the lobule is sometimes inflated as in ordinary leaves. In the perichætial bracts, the lobule, which is often nearly as long as the lobe, is attached to it by a broad fold, and the stylus, which can usually be distinguished even in toothed bracts, appears on the inner edge of the lobule at some little distance from the base; occasionally the stylus is a segment of considerable size. In the perigonial bracts the lobe and the lobule are subequal and are connected by a broad fold to above the middle; the bracts are inflated so as to form hollow pouches for the antheridia, and the stylus, which is carried up on the inner edge of the lobule, usually remains minute.

The perianth of *Frullania* belongs to the hypogonianthous type as described by Spruce.[1] In this type of perianth there are three keels, two lateral and one postical. The significance of this becomes evident if we consider that a perianth is normally formed by the coalescence of three floral leaves or "anthophylls,"[2] including two side-leaves and one underleaf. In case a species has flat leaves and bracts, the anthophylls are flat, their united edges give rise to the keels, and the perianth which results is triangular in section with an antical keel and a flat, postical face corresponding with the flat underleaf. This is the "epigonianthous" type and is well represented by *Lophocolea*. In case a species has complicate leaves, the anthophylls are folded, the folds and not the united edges give rise

[1] On Cephalozia, 5. 1882. The structure of the perianth is fully discussed in this paper, but the points brought forward are so important that it has seemed advisable to call attention to them again.

[2] Spruce, l. c., 3.

to the keels, and the perianth which results is triangular in section with a postical keel corresponding with the folded underleaf. This is the hypogonianthous type. In case no underleaf takes part in the formation of the perianth, the other two anthophylls unite postically and give rise to a perianth which is flattened, either laterally as in *Plagiochila* or antico-postically as in *Radula*. The typical character of the perianth of *Frullania* is often obscured by the interposition of supplementary keels or ridges.

A much less extensive coalescence is sometimes to be found in the involucre, where a bracteole may be connate on one or on both sides with the corresponding bracts. In several of our species the degree of such coalescence is by no means constant and it is only occasionally to be relied on as a specific character. In *F. Bolanderi*, for example, the bracteole may be connate on both sides or on only one side; in *F. Kunzei*, it may be connate on one side or entirely free; while, in *F. Virginica*, all three conditions may be found.

The inflorescence of *Frullania* is a character of great importance and should be determined wherever possible. The sporophyte, on the contrary, which is usually difficult to obtain and very uniform in structure, is of little value in distinguishing species and is not made use of in the following descriptions.

Frullania attains its greatest development in the tropics, where it is represented by numerous species in both hemispheres. In 1884, Spruce[1] divided it into six subgenera, several of which are typically tropical. Five of these subgenera are represented in our flora, one being confined to Florida. Some of Spruce's subgenera are connected by intermediate species and it is impossible to draw rigid lines of distinction between them; still, they are for the most part natural assemblages of forms and are very convenient and useful. In Europe, eight species of *Frullania* have been recorded, three of them belonging to the subgenus *Trachycolea* and the others to *Thiopsiella*. Only one of these species, *F. Tamarisci*, has been certainly found in North America, although two others have been accredited to us. A striking peculiarity of our *Frullaniæ* is the large number of monoicous species among them; no fewer than nine exhibit this character, while the eight European species are all dioicous.

Key to our Subgenera.

Lobule inflated in the upper part only, connected with the lobe by a long fold subparallel with the stem; inflorescence paroicous; perianth trapezoidal in section. Subgenus I. CHONANTHELIA.

[1] Hep. Amaz. et And., 7.

Lobule inflated throughout its whole extent or nearly so, connected with the lobe by a short fold approximately at right angles to the stem.

Lobule about as broad as long.

Underleaves not cordate at base; perianth typically triangular or trapezoidal in section, usually with tubercles or supplementary ridges or both.

Subgenus II. TRACHYCOLEA.

Underleaves cordate at base; perianth simply trigonous and smooth. Subgenus III. HOMOTROPANTHA.

Lobule decidedly longer than broad; perianth simply trigonous and smooth.

Inflorescence dioicous; perianth terminal on a simple lateral branch.

Subgenus IV. THIOPSIELLA.

Inflorescence autoicous; perianth terminal on the stem or a main branch.

Subgenus V. DIASTOLOBA.

SUBGENUS I.—**CHONANTHELIA** Spruce.

Represented by the single species:—

1. **Frullania arietina** Tayl. in G. L. et N. Syn. Hep., 413. 1845.

PLATE I. figs. 1–6.

Paroicous: plants closely appressed to matrix, green, often tinged with yellow or brown: stems irregularly branched: leaves imbricated, the lobe orbicular-ovate, arching over the stem but scarcely cordate at base, plane or slightly decurved at the rounded apex, connected with the lobule by a long fold, subparallel to the stem; lobule tubulose-inflated in the upper half only, the lower forming a plane, irregular or subrhomboidal, subentire expansion; stylus minute, subulate: underleaves contiguous or subimbricated, plane, orbicular, scarcely or not at all auriculate at base, shortly bifid at apex ($\frac{1}{5}$–$\frac{1}{4}$) with subobtuse lobes and sinus, entire or slightly crenulate on the margins; leaf-cells in middle of lobe rather thin-walled but with conspicuous trigones; toward the base the trigones are still more conspicuous and intermediate thickenings become abundant: ♀ inflorescence terminal on a short lateral branch; bracts in one to three pairs, highly connate with the corresponding bracteoles, unequally bifid, the lobe ovate, acute, sparingly toothed, lobule ovate, acute, narrower than the lobe but similarly toothed and bearing a distinct tooth or stylus at or below the middle of its inner edge; brac-

teoles bifid with narrow, acute or acuminate lobes, obtuse sinus and entire margins; perianth immersed to or above the middle, compressed, oblong, abruptly narrowed into a short, broad beak, with two deep postical, and two less pronounced antical keels: ♂ bracts in two or three pairs below the involucre, corresponding bracteoles connate on one side.

Stems 0·18^{mm} in diameter; lobes of leaves 1·20^{mm} long, 1·15^{mm} wide, lobules 0·82^{mm} long, 0·37^{mm} wide, inflated part 0·45^{mm} long; underleaves 0·65^{mm} long and wide; leaf-cells from edge of lobe 0·017^{mm}, from middle 0·029^{mm}, and from base 0·038^{mm} in diameter; bract I,[1] lobe 1·65^{mm} long, 0·80^{mm} wide, lobule 0·80^{mm} long, 0·45^{mm} wide (to point of coalescence with lobe and bracteole); bracteole I, 0·60^{mm} long, 0·40^{mm} wide (to point of coalescence); bract II, lobe 1·20^{mm} long, 0·70^{mm} wide, lobule 0·50^{mm} long, 0·27^{mm} wide, bracteole II, 0·37^{mm} long, 0·25^{mm} wide; perianth 1·80^{mm} long, 0·90^{mm} wide.[2]

On trees; Caloosa River, Florida (J. Donnell Smith).

Chonanthelia is better represented in the American tropics than in any other part of the world, and the range of our only known species extends as far south as Chili. Other members of the subgenus should be looked for in southern Florida. Taylor's original *F. arietina* was apparently a composite species, and I have followed Spruce in restricting the name to plants with paroicous inflorescence.[3] This very unusual character and the peculiar lobules will serve at once to distinguish the plant from all our other *Frullaniæ*.

Subgenus II.—**TRACHYCOLEA** Spruce.

Key to the Species.

Autoicous.

Lobule more than half the size of the lobe. 2. *F. Oakesiana.*

Lobule less than half the size of the lobe, often explanate.

Perianth truncate and abruptly narrowed into a short beak; bracteoles free from the bracts. 4. *F. inflata.*

Perianth not truncate, gradually narrowed into a short beak; bracteoles connate on one side with bracts. 5. *F. Catalinæ.*

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[1] The Roman numerals refer to the position of bract or bracteole: thus, I signifies the bract or bracteole next to the perianth; II, the bract or bracteole of the next outer row; and so on.

[2] The species of *Frullania* are of course not constant in size, and the measurements, which are taken from average-sized plants, are merely of comparative value.

[3] The specimens of *F. arietina* in the Taylor herbarium, all of which came from Demerara, the second of the localities mentioned in the Synopsis, are paroicous and agree with those described and distributed by Spruce.

Dioicous.

Lobes not cordate at base; leaf-cells in middle of lobe with inconspicuous trigones and no intermediate thickenings; branches often terminating in upright, leafless flagella with squarrose underleaves. 3. *F. Bolanderi.*

Lobes cordate or auriculate at base; leaf-cells in middle of lobe with conspicuous trigones and occasional or frequent intermediate thickenings; branches not terminating in leafless flagella.

Leaves strongly squarrose when moist. 7. *F. squarrosa.*

Leaves scarcely or not at all squarrose when moist.

Lobule usually explanate. 6. *F. riparia.*

Lobule usually inflated.

Lobule inflated in upper and outer parts, compressed below; underleaves dentate or crenate on the sides above the middle; perianth strongly tuberculate with more or less distinct supplementary ridges. 8. *F. Brittoniæ.*

Lobule inflated throughout, underleaves entire or unidentate on the sides.

Perianth with one or more distinct roughened supplementary ridges both antically and postically. 9. *F. Virginica.*

Perianth smooth and without distinct supplementary ridges. 10. *F. Eboracensis.*

2. **Frullania Oakesiana** Aust., Proc. Acad. Phila. for 1869: 226.

PLATE I. figs. 7–15.

Autoicous: plants closely appressed to matrix, reddish-brown, varying to greenish: stems irregularly pinnate; leaves imbricated, the lobe orbicular to ovate, slightly squarrose, arching over the stem but not cordate at base, slightly decurved at the rounded apex, entire or nearly so; lobule large, galeate, truncate at base, close to the stem; stylus minute: underleaves distant or subimbricated, plane, obovate or rhombic, bifid about one-third with acute lobes and narrow sinus, margin entire or unidentate on one or both sides: leaf-cells in middle of lobe with rather thick walls and inconspicuous trigones but without intermediate thickenings: ♀ inflorescence terminal on the stem or a main branch; bracts in about two pairs deeply and unequally bifid, the lobe ovate, rounded at the apex, entire, lobule about as long as the lobe but narrower, ovate, obtuse or acute, entire but bearing a

minute tooth or stylus at about the middle of its inner edge; bracteole connate on one side, ovate, bifid with acute lobes and sinus, otherwise entire; perianth long-exserted, inflated or slightly compressed at sides, obovate, narrowed into a short, broad beak, with a broad usually two-angled postical keel and often with additional antical and postical ridges interposed: ♂ bracts in about two pairs occupying a short lateral branch near the involucre.

Stems 0·10^{mm} in diameter; lobes of leaves 0·45^{mm} long, 0·35^{mm} wide, lobules 0.23^{mm} long and wide; underleaves 0·18^{mm} long, 0·14^{mm} wide; leaf-cells from edge of lobe 0·013^{mm}, from middle 0·019^{mm} in diameter, and from base 0·025^{mm} long, 0·015^{mm} wide; bract I, lobe 0·55^{mm} long, 0·30^{mm} wide, lobule 0·55^{mm} long, 0·23^{mm} wide; bracteole I, 0·45^{mm} long, 0·018^{mm} wide; bract II, lobe 0·45^{mm} long, 0·23^{mm} wide; bracteole II, 0·30^{mm} long, 0·12^{mm} wide; perianth 1·00^{mm} long, 0·65^{mm} wide.

On trees, mostly at high altitudes; White Mountains, New Hampshire (Oakes, Austin, etc.): Mount Mansfield, Vermont (Farlow). Distributed in Hep. Bor.-Amer. *n. 105c*, and in Hep. Amer. *n. 49.*

This delicate little species seems to be quite local; it has been collected perhaps a half dozen times in the White Mountain region, where it was discovered many years ago by Oakes, but I have seen specimens from only one other locality. Except for its small size, it would not be difficult of detection; its reddish color usually serves to distinguish it from *F. Eboracensis,* a very common mountain species at lower altitudes, and there is little danger of its being confused with *F. Asagrayana*, the only other species found in the White Mountains. Aside from its color, *F. Oakesiana* differs from *F. Eboracensis* in its autoicous inflorescence, in the areolation of its leaves, in its large lobule, and in the additional ridges on its perianth.

3. **Frullania Bolanderi** Aust., Proc. Acad. Phila. for 1869: 226.

PLATE II.

Frullania Petalumensis Gottsche in Bolander, Catalogue of the Plants growing in the vicinity of San Francisco, 1870.

Frullania Hallii Aust., Bull. Torrey Bot. Club, vi: 20. 1875.

Dioicous: plants closely appressed to matrix, dark green, varying to reddish: stems irregularly pinnate, the branches often prolonged at right angles to the matrix as flagella without leaves, except a few toward the extremity, and with squarrose underleaves: leaves distant or subimbricated, the lobe ovate, somewhat squarrose when moist, arching over the stem but not cordate at base, rounded at the apex; lobule large, galeate, truncate at base, close to the stem; stylus

minute: underleaves distant, rhombic-ovate, bifid about one-third with subacute lobes and sinus, margin entire or bearing one or two teeth on the sides: leaf-cells of lobe with rather thick walls, trigones more conspicuous near the margin, intermediate thickening not developed: ♀ inflorescence terminal on the stem or a main branch; bracts in two or three pairs, unequally bifid, the lobe ovate, rounded at the apex, entire or nearly so, lobule narrower than the lobe, ovate, rounded or obtuse, entire but bearing a minute tooth or stylus near the middle of its inner edge; bracteole connate on one or both sides, very variable, ovate, normally bifid about one-third with acute lobes and sinus, but sometimes rounded or merely emarginate at apex, sometimes with three or four more or less distinct teeth; perianth about half-emersed, obovate, narrowed into a short, broad beak, with a distinct, usually two-angled, postical keel and one or more antical and postical supplementary ridges: ♂ bracts in six to ten pairs, occupying a short lateral branch and forming an oblong spike.

Stems 0·10^{mm} in diameter; lobes of leaves 0·35^{mm} long, 0·30^{mm} wide, lobules 0·25^{mm} long and wide; underleaves 0·18^{mm} long, 0·15^{mm} wide; leaf-cells from edge of lobe 0·016^{mm}, from middle 0·027, and from base 0·035^{mm} in diameter; bract I, lobe 0·80^{mm} long, 0·50^{mm} wide, lobule 0·50^{mm} long (to point of coalescence), 0·25^{mm} wide; bracteole I, 0·65^{mm} long, 0·35^{mm} wide; bract II, lobe 0·65^{mm} long, 0·40^{mm} wide, lobule 0·35^{mm} long, 0·15^{mm} wide; bracteole II, 0·60^{mm} long, 0·20^{mm} wide; perianth 1·25^{mm} long, 0·80^{mm} wide.

On trees; west of the Rocky Mountains, from California to British Columbia. Distributed in Hep. Bor.-Amer. *n. 105b*, and in Hep. Amer. *n. 28*.

Frullania Bolanderi is the most widely distributed *Trachycolea* of the Pacific Coast region and is common in many places. There is little danger of confounding it with any other western species, and the remarkable, upright, leafless flagella, which are usually produced in greater or less profusion, are a ready means of distinguishing it from the eastern species which it most closely resembles. Its nearest ally is perhaps *F. Oakesiana*, which, aside from the absence of flagella, has a narrower perianth than *F. Bolanderi* and an autoicous inflorescence. *F. Eboracensis* occasionally produces flagella-like branches, but they are always leafy and are a rather unusual feature of the plant; its smaller lobule, different areolation, and smooth trigonous perianth will also serve to distinguish it. *Frullania Hallii* is said by its author to be monoicous; the specimens of Hall and of Macoun, however, which I have been able to examine are all dioicous

so that the monoicous character is at least very exceptional. Another point of distinction which Austin gives between his two species is in the character of the innermost bracteole—in *F. Hallii* this is said to be entire or slightly emarginate at the apex, while in *F. Bolanderi* it is said to be "acutely 2 (–4) toothed." All of these conditions are sometimes found together, and the other less important differences given are no more constant.

4. **Frullania inflata** Gottsche in G. L. et N. Syn. Hep., 424. 1845.

Plate III.

Autoicous: plants closely appressed to matrix, brownish-green varying to reddish: stems irregularly pinnate: leaves imbricated, the lobe orbicular, arching over the stem but not cordate at base, decurved at the rounded apex, entire; lobule galeate, truncate at base, inflated especially in the upper and outer parts, separated from the stem by about one-fourth its width; stylus minute, subulate: underleaves distant, orbicular or obovate, bifid about one-third with acute or obtuse lobes and sinus, entire or nearly so: leaf-cells of lobe rather thick-walled with inconspicuous trigones and no intermediate thickenings: ♀ inflorescence terminal on the stem or a main branch; bracts in two or three pairs unequally bifid, the lobe ovate to obovate, rounded at apex, entire, lobule shorter and narrower than the lobe, ovate, rounded to subacute at the apex, bearing a small tooth or stylus below the middle of the inner edge, otherwise entire; bracteole free from bracts, ovate, deeply bifid with acute or obtuse lobes and sinus, entire or bearing one or two minute teeth toward the base; perianth exserted, more or less compressed when young, inflated when old, obovate, abruptly narrowed into a short, broad beak, with a distinct, angled, postical keel and usually with one or more supplementary antical and postical ridges: ♂ bracts in about two pairs, occupying a short lateral branch near the involucre and forming a short ovoid spike.

Stems $0{\cdot}12^{mm}$ in diameter; lobes of leaves $0{\cdot}55^{mm}$ long, $0{\cdot}60^{mm}$ wide, lobules $0{\cdot}25^{mm}$ long and wide; underleaves $0{\cdot}30^{mm}$ long and wide; leaf-cells from edge of lobe $0{\cdot}017^{mm}$, from middle $0{\cdot}024^{mm}$ and from base $0{\cdot}032^{mm}$ in diameter; bract I, lobe $0{\cdot}85^{mm}$ long, $0{\cdot}50^{mm}$ wide, lobule $0{\cdot}65^{mm}$ long, $0{\cdot}40^{mm}$ wide; bracteole I, $0{\cdot}65^{mm}$ long, $0{\cdot}40^{mm}$ wide; bract II, lobe $0{\cdot}65^{mm}$ long, $0{\cdot}50^{mm}$ wide, lobule $0{\cdot}60^{mm}$ long, $0{\cdot}30^{mm}$ wide; bracteole II, $0{\cdot}65^{mm}$ long, $0{\cdot}40^{mm}$ wide; perianth $0{\cdot}90^{mm}$ long, $0{\cdot}65^{mm}$ wide.

On trees; "Whastite Red River (Beyrich)": Baton Rouge, Louisiana (Joor): Point a la Hache, Louisiana (Langlois): Georgetown,

D. C. (Coville): Austin, Texas (Underwood). On cypress pickets; St. Martinsville, Louisiana (Langlois). Distributed as *Frullania Virginica* in Hep. Amer. *n. 68.*

The determination of the plants which I have called *Frullania inflata* is based on a small scrap so named from Austin's herbarium. This material was collected in Mississippi by E. Hall, and no nearer indication of its station is given. The species is apparently not rare in the western Gulf States and it is probably commoner elsewhere than collections would seem to indicate. At first sight the perianth of *F. inflata* resembles that of *F. Virginica*, especially when young, in having distinct supplementary ridges, but these ridges are never tuberculate as in that species and are usually quite smooth. It also differs from *F. Virginica* in its autoicous inflorescence, in its leaf-lobes, which are scarcely if at all cordate at the base, and in its areolation, the cells of the lobes having more uniformly thickened walls. There is little danger of confusing it with any other southern *Trachycolea.* Our New England *F. Oakesiana* is a much smaller plant than *F. inflata* and its large lobule and different perianth will readily serve to distinguish it.

5. **Frullania Catalinæ** n. sp.

PLATE IV.

Autoicous: plants growing in depressed tufts, reddish-brown, sometimes tinged with greenish: stems irregularly pinnate: leaves imbricated, the lobe ovate, squarrose when moist, arching over the stem but not cordate at base, slightly decurved at the rounded or obtuse apex, entire; lobule broadly galeate, inflated, often imperfectly developed as a water-sac or wholly explanate, separated from the stem by about one-fourth its width; stylus subulate, usually minute: underleaves distant, broadly rhombic, bifid to about the middle with obtuse or subacute lobes and sinus, entire or more commonly unidentate on the sides: leaf-cells with slightly thickened walls, inconspicuous trigones and no intermediate thickenings: ♀ inflorescence terminal on the stem or a main branch; bracts in two or three pairs, unequally bifid, the lobe ovate, rounded or obtuse at the apex, entire or vaguely crenulate at base; lobule shorter and narrower, ovate, rounded to subacute at the apex, bearing a distinct tooth or segment (stylus) at or above the middle of the inner edge, otherwise entire; bracteole connate on one side with bract, narrowly ovate, bifid one-third or more with lanceolate lobes and narrow sinus, otherwise entire; perianth about half-exserted, somewhat compressed at least in the upper part, fusiform to pyriform, gradually narrowed

into a short, broad beak, with a distinct angled postical keel and one or more less pronounced antical and postical ridges : ♂ bracts in one or two pairs, occupying a short branch near the involucre and forming a short, oval spike.

Stems 0·10^{mm} in diameter ; lobes of leaves 0·60^{mm} long, 0·55^{mm} wide, lobules 0·16^{mm} long, 0·23^{mm} wide (when explanate, 0·30^{mm} long, 0·23^{mm} wide); underleaves 0·30^{mm} long, 0·27^{mm} wide ; leaf-cells from edge of lobe 0·016^{mm}, from middle 0·020^{mm} in diameter and from base 0·030^{mm} long, 0·020^{mm} wide ; bract I, lobe 1·20^{mm} long, 0·70^{mm} wide, lobule 0·80^{mm} long, 0·45^{mm} wide ; bracteole I, 0·75^{mm} long, 0·30^{mm} wide, bract II, lobe 0·90^{mm} long, 0·60^{mm} wide, lobule 0·60^{mm} long, 0·30^{mm} wide; bracteole II, 0·65^{mm} long, 0·20^{mm} wide; perianth 1·50^{mm} long, 0·75^{mm} wide.

On rocks in a cañon ; Catalina Island, California (McClatchie).

It will be seen from the foregoing description that *F. Catalinæ* is closely related to *F. inflata*. Its leaves, however, are much more squarrose than in that species, its bracteoles are connate on one side, and its perianth, antheridial spike, and underleaves are different in shape. From *F. Bolanderi* it differs most strikingly in its larger size, autoicous inflorescence and absence of flagella.

The first four species which I have placed in *Trachycolea* form a rather distinct group by themselves and have the following characters in common :—(1) the leaf-lobes are scarcely or not at all cordate at base ; (2) the cells of the lobes are pretty uniformly thickened, having neither conspicuous trigones nor intermediate thickenings ; (3) the postical keel of the perianth is more or less two-angled, so that the perianth is typically trapezoidal in section, although this condition is usually obscured by the interposition of supplementary ridges ; (4) the keels and ridges of the perianth are not tuberculate, although they are sometimes slightly roughened or sinuous on the edges. In all of these points they differ from such typical *Trachycoleae* as *F. dilatata*, *F. Virginica* and *F. squarrosa*, and seem to find their nearest allies in the last three South American *Frullaniæ*[1] which Spruce includes under *Chonanthelia*. Spruce[2] suggests, however, that these three species might better be placed in *Trachycolea*, with which they certainly seem to have more in common.

[1] Hep. Amaz. et And., 29. 1884. [2] L. c., 30.

6. **Frullania riparia** Hampe in Lehmann: Pugillus, vii, 14. 1838.

Frullania œolotis Mont. et Nees in Nees: Europ. Leberm., iii: 210. 1838 (nomen nudum).

Frullania œolotis Nees in G. L. et N. Syn. Hep., 417. 1845.

PLATE V.

Dioicous: plants growing in depressed tufts, green, sometimes tinged with brownish: stems loosely and irregularly pinnate: leaves distant to somewhat imbricated, the lobe ovate, slightly squarrose when moist, arching over the stem and cordate at base, plane or slightly decurved at rounded apex, entire or vaguely sinuate; lobule when inflated a galeate sac truncate at base, when explanate (the usual condition) a small lanceolate lamina; stylus minute: underleaves distant, rhombic to orbicular, bifid one-third or more with subacute lobes and sinus, entire or subdentate on the edges: leaf-cells in middle of lobe with slightly thickened walls, distinct trigones and occasional intermediate thickenings, the latter disappearing and the trigones becoming more pronounced toward the base: ♀ inflorescence terminal on the stem or a main branch; bracts in two or three pairs, deeply and unequally bifid, the lobe ovate, obtuse, entire; lobule shorter and narrower, lanceolate, acute, bearing a small tooth or stylus on the inner edge near the base, otherwise entire; bracteole free from bracts, narrowly ovate, bifid about one third with subacute lobes and narrow sinus, irregularly dentate or subentire on margin: perianth and ♂ spike not seen.

Stems 0·12^{mm} in diameter; lobes of leaves 0·60^{mm} long, 0·48^{mm} wide, lobules (when explanate) 0·30^{mm} long, 0·12^{mm} wide; underleaves 0·30^{mm} long, 0·30^{mm} wide; leaf-cells from edge of lobe 0·015^{mm}, from middle 0·018^{mm} and from base 0·030^{mm} in diameter.

On trees and rocks, mostly in shaded places; from New England westward to Minnesota and southward to the Gulf of Mexico. Distributed in Musc. Alleg. *n. 268* (as *F. dilatata*, var. 2), in Hep. Bor.-Amer. *n. 101* (as *F. œolotis*), and in Hep. Amer. *n. 140* (as *F. œolotis*).

Frullania riparia was first described from sterile material; and, although a description of the involucre is added in the Synopsis Hepaticarum, the perianth and antheridial plant are apparently still unknown. In the absence of these data it is not possible to point out definitely the relationships of the species within the genus, but the general characters of leaves and underleaves, the dioicous inflorescence and the position of the female flowers show with little doubt that it is a true *Trachycolea*. Its nearest relative seems to be the Italian *F. Cesatiana* De Not.,[1] which is likewise incompletely

[1] Mem. Accad. delle Sci. di Torino, II, xxii: 383, *pl. 5*. 1865.

known, and Professor Massalongo[1] suggests that the two species may be identical. The Italian plant shows the same general appearance as ours, the same characters in lobes, underleaves and areolation, and the same great variability in the lobules, but it shows also slight differences in bracts and bracteoles. It seems safest, therefore, to keep the plants apart until both are better known. *F. riparia* is most readily distinguished from its American allies by its lobules, which are rarely inflated but usually wholly or partially explanate. Of course a character of this sort is not very satisfactory, as several other species may show a similar variability in the shape of the lobule if growing in sheltered places. *F. riparia* also differs from *F. squarrosa* in its looser habit, less squarrose and narrower lobes and in its free bracteoles; from *F. Virginica* and *F. Eboracensis*, in its larger size, ovate lobes, and broader underleaves.

7. **Frullania squarrosa** (Bl. R. et Nees) Dumort., Recueil d' Obs. sur les Jung., 13. 1835.

Jungermannia squarrosa Bl. R. et Nees, Nova Acta Acad. Caes. Leop., xii: 219. 1824.

PLATE VI.

Dioicous: plants closely appressed to matrix or more commonly growing in loose, wide mats, green, varying to reddish-brown: stems irregularly pinnate: leaves densely imbricated, the lobe rolled about the stem when dry, strongly squarrose when moist, very fragile in texture, broadly ovate, arching over the stem and cordate or auriculate at base, rounded at the apex, entire; lobule galeate, inflated, especially in upper and outer parts, compressed at base, separated from the stem by about one-fourth its width; stylus minute: underleaves subimbricated, orbicular, plane or nearly so, entire or sparingly repand-dentate: leaf-cells from middle of lobe rather thick-walled with distinct trigones and intermediate thickenings: ♀ inflorescence terminal on a short lateral branch; bracts in about three pairs, unequally bifid, the lobe ovate to orbicular ovate, rounded at the apex, entire; lobule ovate or broadly lanceolate, acute, bearing one or more small subulate teeth near the base on the inner edge, otherwise entire; bracteole connate on one or both sides with bracts, approximately orbicular, deeply bifid to the middle or beyond with acute lobes and sinus, entire or slightly toothed or lobed toward the base, often revolute on the borders: perianth oblong, compressed, narrowed into a short broad beak, strongly unicarinate postically

[1] Atti del Congr. Nazionale di Bot. Crittog. in Parma, 10 (sep.) 1887.

and bearing numerous scattered tubercles or scales, especially on the keels : ♂ plant not seen.

Stem 0·15^{mm} in diameter; lobes of leaves 0·80^{mm} long and wide, lobule 0·23^{mm} long, 0·20^{mm} wide ; underleaves 0·45^{mm} long, 0·35^{mm} wide; leaf-cells from edge of lobe 0·016^{mm} in diameter, from middle 0·027^{mm} long, 0·019^{mm} wide, and from base 0·030^{mm} long, 0·023^{mm} wide ; bract I, lobe 1·00^{mm} long, 0·80^{mm} wide, lobule 0·75^{mm} long, 0·40^{mm} wide ; bracteole I, 0·75^{mm} long, 0·60^{mm} wide ; bract II, lobe 0·90^{mm} long, 0·75^{mm} wide, lobule 0·65^{mm} long, 0·30^{mm} wide ; bracteole II, 0·55^{mm} long, 0·30^{mm} wide; perianth 1·50^{mm} long, 0·90^{mm} wide.

On trees and rocks, from Connecticut to Ohio and southward; common in the Southern States. Distributed in Hep. Bor.-Amer. *n. 100* and in Hep. Amer. *n. 94.*

Frullania squarrosa is the most cosmopolitan of all our species, occurring almost everywhere in the warmer parts of the earth. The species is commonly sterile and plants with perianths are extremely rare, although female plants without perianths are not unusual. Even in a sterile state there is no difficulty in distinguishing the plant, because the densely imbricated leaves, closely appressed to the stem when dry and strongly squarrose when moist, are unlike anything found in our other species. In the Southern States a form with the lobules pretty uniformly explanate sometimes occurs : this is apparently *Frullania ericoides* Nees, but there seems to be no good reason for keeping it distinct from *F. squarrosa* even as a variety.

8. **Frullania Brittoniæ** n. sp.

Frullania dilatata Underw. in Gray: Manual of Botany, sixth edition, 706. 1890 (not (L.) Dum.).

Plate VII. figs. 1–12.

Dioicous : plants growing in wide depressed tufts, reddish-brown varying to greenish : stems irregularly pinnate: leaves imbricated, the lobe reniform-orbicular arching over the stem and strongly cordate or auriculate at base, plane or decurved at the rounded apex, entire ; lobule galeate, close to the stem, truncate and compressed at base, inflated in upper and outer parts ; stylus subulate, three to five cells wide at base : underleaves distant, broadly orbicular or elliptical, bifid about one third with obtuse, acute or apiculate lobes and acute sinus, irregularly dentate or crenulate on the sides above the middle: leaf-cells at margin of lobe with rather thin walls, distinct trigones and occasional intermediate thickenings, the last becoming fewer, the walls thicker and the trigones more conspicuous as we pass inward: ♀ inflorescence terminal on the stem or a principal branch; bracts in two or three pairs, unequally bifid, the lobe ovate, rounded

or obtuse (sometimes apiculate), entire or slightly crenulate, lobule shorter and narrower, ovate or lanceolate, subacute or apiculate, bearing a small tooth or stylus at or below the middle of the inner edge, otherwise entire ; bracteole free or slightly connate on one side with bract, ovate, bifid one fourth or more with acute lobes and sinus, entire or unidentate on one or both sides; perianth emersed, obovate, truncate above and abruptly narrowed into a long, slender beak, compressed at the sides and with a broad postical keel and one or more short, supplementary antical and postical ridges, the whole surface being provided with scattered tubercles especially numerous on keels and ridges : ♂ bracts in many pairs, occupying a short lateral branch and forming an oblong spike.

Stems 0·18^{mm} in diameter ; lobes of leaves 0·60^{mm} long, 0·75^{mm} wide, lobules 0·25^{mm} long and wide ; underleaves 0·30^{mm} long, 0·37^{mm} wide; leaf-cells from edge of lobe 0·014^{mm}, from middle 0·022^{mm} in diameter and from base 0·032^{mm} long, 0·025^{mm} wide ; bract I, lobe 1·35^{mm} long, 0·75^{mm} wide, lobule 1·00^{mm} long, 0·50^{mm} wide ; bracteole I, 0·85^{mm} long, 0·50^{mm} wide ; bract II, lobe 1·05^{mm} long, 0·65^{mm} wide, lobule 0·75^{mm} long, 0·65^{mm} wide; bracteole II, 0·70^{mm} long, 0·35^{mm} wide ; perianth 1·90^{mm} long, 1·20^{mm} wide.

On rocks and trees; Central New York (Underwood) : Holston River and Slemp's Creek, Virginia (Mrs. Britton and Miss Vail) : Meriden, Connecticut (Evans): Canton, Illinois (Wolf): Easton, Pennsylvania (James). Distributed in Hep. Amer. *n. 48* (as *F. dilatata*); in some sets there is admixture with *F. Eboracensis.*

In a sterile condition the present plant strikingly resembles the European *F. dilatata*, and it is little wonder that they have been considered the same. The involucre and perianth, however, afford safe points of distinction : in *F. dilatata* the lobes of the bracts are broader than in our plant, the innermost bracteole is bifid with its lobes deeply cut into two or three segments, and the perianth is simply trigonous and narrowed into a short, broad beak. The long, slender beak of the perianth is indeed a most peculiar feature of *F. Brittoniæ* and serves, together with the numerous tubercles, to distinguish the species from all other North American *Frullaniæ.* But, even in the absence of inflorescence, there is little danger of mistaking the present species, for the points which ally it with *F. dilatata* separate it from other *Trachecoleæ*, viz., the larger size of the plant, the curious inflation of the lobule and the broad underleaves with their peculiar dentation. I take pleasure in naming this distinct and beautiful species in honor of Mrs. Elizabeth G. Britton, whose careful work on American mosses is so highly appreciated by bryologists.

9. **Frullania Virginica** Gottsche in Lehmann, Pugillus, viii: 19. 1844.

Frullania saxicola Aust., Proc. Acad. Phila. for 1869: 225.

Frullania Sullivantii Aust., Proc. Acad. Phila. for 1869: 226.

PLATE VIII.

Dioicous: plants closely appressed to matrix, green, varying to brownish: stems irregularly pinnate: leaves imbricated, the lobe suborbicular, arching over the stem and cordate at base, decurved at the rounded apex, entire; lobule galeate, truncate at base, somewhat inflated throughout, separated from the stem by about one-sixth its width; stylus minute, two or three cells wide at base: underleaves distant, rhombic-ovate, bifid about one-third with subacute lobes and acute sinus, entire or rarely unidentate on the sides: leaf-cells of lobe rather thick-walled with conspicuous trigones and intermediate thickenings, especially toward the base: ♀ inflorescence terminal on the stem or a main branch; bracts in two or three pairs, unequally bifid, the lobe squarrose, ovate to orbicular, rounded at the apex, entire, lobule ovate to lanceolate, acute or apiculate, bearing a small tooth-like segment or stylus at or above the middle of the inner edge, otherwise entire; bracteole free or connate on one or both sides, ovate, bifid one-fourth to one-third with acute lobes and sinus, margins entire, crenulate or slightly dentate; perianth half exserted, somewhat compressed on the sides, obovate, abruptly narrowed into a short, broad beak, with a distinct angled postical keel and usually with two or more supplementary antical and postical ridges, more or less tuberculate, particularly on keels and ridges: ♂ bracts in many pairs, occupying the end or middle part of a short lateral branch and forming an oblong spike.

Stems 0·10^{mm} in diameter; lobes of leaves 0·55^{mm} long, 0·45^{mm} wide, lobules 0·28^{mm} long, 0·18^{mm} wide; underleaves 0·22^{mm} long, 0·15^{mm} wide; leaf-cells from edge of lobe 0·014^{mm}, from middle 0·018^{mm}, and from base 0·025^{mm} in diameter; bract I, lobe 0·80^{mm} long, 0·65^{mm} wide, lobule 0·75^{mm} long, 0·35^{mm} wide; bracteole I, 0·80^{mm} long, 0·55^{mm} wide; bract II, lobe 0·65^{mm} long, 0·55^{mm} wide, lobule 0·65^{mm} long, 0·30^{mm} wide; bracteole II, 0·60^{mm} long, 0·25^{mm} wide; perianth 1.35^{mm} long, 1·00^{mm} wide.

On trees or, more rarely, on rocks; from Canada to the Gulf of Mexico: rare in the north but becoming abundant southward. Distributed in Musc. Alleg. *n. 267* (as *F. dilatata*, var. 1) and in Hep. Bor.-Amer. *n. 103* and *n. 104* (as *F. saxicola*).

It will be seen that there have been included under this very variable species two forms which were considered distinct by Austin.

The following statement is quoted from the description by that author of his *Frullania saxicola*:—"Perianth longer than in *F. Virginica* and more exserted, but angled much in the same manner; however, the angles are never crested, and the 'style' or mouth is very different; (tubular and considerably elongated in *F. Virginica*)." The perianth is so extremely variable an organ that the differences brought forward are hardly sufficient to keep the plants distinct, particularly as the characters derived from leaves, underleaves and involucres are almost identical in the two. The short beak of *F. saxicola* is at first sight a striking peculiarity, but there are intermediate grades between it and the typical beak of *F. Virginica*, while the absence of crests is a rather inconstant feature In his account of *F. Sullivantii*, Austin gives no direct comparison with *F. Virginica* but indicates the following differences in his description: —the larger lobule, the connate bracteole, the fewer keels in the perianth. Differences as great as these may sometimes be found in a single specimen. I have been able to study the types of both of Austin's species and find no greater differences than those enumerated.

10. **Frullania Eboracensis** Gottsche in Lehmann, Pugillus, viii: 14. 1844.

Frullania saxatilis Lindenb, in G. L. et N. Syn. Hep., 424. 1844.

Frullania microscypha Tayl., Lond. Jour. Bot., v: 402. 1846.

Frullania læviscypha Tayl., l. c., v: 403. 1846.

Frullania nana Tayl., l. c., v: 404. 1846.

PLATE IX. figs. 1–11.

Dioicous: plants closely appressed to matrix, usually green but often tinged with brown or red; stems irregularly pinnate, sometimes flagelliferous; leaves imbricated, the lobe suborbicular, arching over the stem and cordate at base, rounded at the slightly decurved apex, entire; lobule galeate, truncate at base, separated from the stem by about one-sixth its width; stylus minute, two or three cells wide at base: underleaves distant, ovate or rhombic-ovate, bifid about one-third with subacute lobes and sinus, entire or obscurely unidentate on the sides: leaf-cells of lobe rather thick-walled with trigones and intermediate thickenings, the latter becoming fewer toward the base: ♀ inflorescence terminal on the stem or a main branch; bracts in two or three pairs, unequally bifid, the lobe ovate, rounded at the apex, entire or slightly crenulate toward base; lobule narrower than the lobe, ovate, acute or obtuse, bearing a small tooth-like segment or stylus at about the middle, otherwise subentire; bracteole free or connate on one side, ovate, bifid one-third or more,

with acute lobes and sinus, entire or irregularly dentate on the sides; perianth obovate or obcuneate, more or less compressed, abruptly narrowed into a short, broad beak, with a distinct, sometimes two-angled postical keel but without distinct supplementary ridges, smooth or slightly roughened on lateral keels, never tuberculate: ♂ spike oblong, occupying a short lateral branch, bracts in many pairs.

Stem 0·10^{mm} in diameter, lobes of leaves 0·45^{mm} long and wide, lobules 0·21^{mm} long and wide; underleaves 0·20^{mm} long, 0·15^{mm} wide; leaf-cells from edge of lobe 0·014^{mm}, from middle 0·017^{mm} in diameter, and from base 0·030^{mm} long, 0·017^{mm} wide; bract I, lobe 0·80^{mm} long, 0·45^{mm} wide, lobule 0·60^{mm} long, 0·30^{mm} wide; bracteole I, 0·55^{mm} long, 0·23^{mm} wide; bract II, lobe 0·60^{mm} long, 0·38^{mm} wide, lobule 0·45^{mm} long, 0·18^{mm} wide; bracteole II, 0·45^{mm} long, 0·15^{mm} wide; perianth 1·10^{mm} long, 0·75^{mm} wide.

On trees and rocks; from Canada to Florida and westward to Minnesota: very common in the mountains and in northern regions. Distributed in Hep. Bor.-Amer. *n. 105*, in Hep. Amer. *n. 27*, and in Can. Hep. *n. 1.*

Frullania Eboracensis is characteristically a northern species and reaches the south only as a rarity, whereas the reverse is true for *F. Virginica.* In a sterile condition the two species sometimes resemble each other so closely that it is difficult if not impossible to tell them apart and we must depend upon perianths for differential characters which are constant. The perianth of *F. Eboracensis* is very variable both in shape and in the character of the postical keel, but it has the unusual feature among *Trachycoleæ* of being smooth and without supplementary ridges. In some cases, however, there is a slight trace of an antical ridge, although this seems to be an exceptional condition. *F. Virginica* is of course distinguished by its tuberculate perianth with distinct supplementary ridges.

Subgenus III.—**HOMOTROPANTHA** Spruce.

Represented by the single species:—

11. **Frullania plana** Sulliv., Mem. Amer. Acad., new series, iv: 175. 1849.

Plate IX. figs. 12–21.

Autoicous: plants growing in wide depressed tufts, green, sometimes tinged with brown: stems irregularly pinnate or bipinnate: leaves imbricated, the lobe orbicular, arching over the stem and strongly cordate or auriculate at the base, decurved at the rounded apex, entire; lobule galeate, close to the stem, truncate at base, inflated particularly in upper and outer parts, stylus minute: under-

leaves distant, reniform, cordate at base, bifid about one-fourth, with obtuse or subacute lobes and sinus: leaf-cells of lobe rather thick-walled with conspicuous trigones and intermediate thickenings: ♀ inflorescence terminal on a short, simple, lateral branch; bracts in about three pairs, unequally bifid, the lobe ovate, rounded at the apex, irregularly crenulate, lobule shorter and narrower, ovate, rounded at apex, irregularly crenulate and bearing at or below the middle of the inner edge a tooth-like, often laciniate segment or stylus; bracteole free from bracts, ovate, deeply bifid with subacute lobes and sinus, the lobes variously laciniate, dentate or crenulate; perianth about half exserted, oblong or obovate, narrowed into a short, broad beak, compressed on the sides, with a broad postical keel and a shallow antical sulcus, smooth: ♂ spike terminal on a short lateral branch, globose, bracts in two or three pairs.

Stems 0·18^{mm} in diameter; lobes of leaves 0·60^{mm} long, 0·75^{mm} wide, lobules 0·18^{mm} long and wide; underleaves 0 30^{mm} long, 0·40^{mm} wide; leaf-cells from edge of lobe 0·014^{mm}, from middle 0·019^{mm}, and from base 0·028^{mm} in diameter; bract I, lobe 1·00^{mm} long, 0·65^{mm} wide, lobule 0·60^{mm} long, 0·35^{mm} wide; bracteole I, 0·65^{mm} long, 0·40^{mm} wide; bract II, lobe 0·80^{mm} long, 0·60^{mm} wide, lobule 0·45^{mm} long, 0·30^{mm} wide; bracteole II, 0·50^{mm} long, 0·40^{mm} wide; perianth 1·90^{mm} long, 0·90^{mm} wide.

On shaded rocks: French Broad River, Tennessee (Sullivant); Closter, New Jersey (Austin); Sand Lake, New York (Peck); Woodbridge, Connecticut (Evans). Distributed in Musc. Alleg. *n. 269* (as *F. dilatata*, var. 3) and in Hep. Bor.-Amer. *n. 102.*

Frullania plana is by no means a typical *Homotropantha* but it shows its relationships with this group rather than with *Trachycolea* by the union of the following characters: – (1) the broad, cordate underleaves, (2) the autoicous inflorescence, (3) the female flowers borne on simple lateral branches, and (4) the smooth trigonous perianth. The lobule, however, although small for the size of the plant, is never reflexed, as in *F. replicata*, etc. The present plant is usually sterile, but its peculiar underleaves will serve to distinguish it even in this condition.

Subgenus IV.—**THIOPSIELLA** Spruce.

Key to the Species.

Underleaves reflexed, at least toward the apex.

Lobes acuminate or acute; underleaves not crispate at base; bracts subentire; innermost bracteole connate on both sides.
12. *F. Nisquallensis.*

Lobes acute or obtuse; underleaves strongly crispate at base; bracts more or less dentate; innermost bracteole free.
15. *F. Tamarisci.*

Lobes obtuse or rounded; underleaves not crispate at base; bracts entire or slightly dentate; innermost bracteole usually free. 14. *F. Asagrayana.*

Underleaves plane or nearly so.

Lobes marked with a distinct line of discolored cells; underleaves entire on the sides, sometimes auriculate at base; stylus a conspicuous disc-like process; stylus of lobule of bract a distinct segment. 14. *F. Asagrayana.*

Lobes marked with a distinct line of discolored cells; underleaves often unidentate on the sides, never auriculate at base; stylus small or minute; stylus of lobule of bract not distinct, replaced by a cluster of fine laciniæ or cilia.
13. *F. Franciscana.*

Lobes with or without scattered discolored cells; underleaves entire on the sides; stylus minute; stylus of lobule of bract a distinct segment. 16. *F. Californica.*

12. **Frullania Nisquallensis** Sulliv., Mem. Amer. Acad., new series, iv: 175. 1849.

PLATE X.

Dioicous: plants robust, growing in broad, depressed tufts, reddish-brown, usually tinged with yellow or green: stems mostly bipinnate: leaves imbricated, the lobe ovate, arching over the stem and cordate at base, strongly reflexed at the acute or acuminate apex, margin entire; lobule separated from the stem by about its own width, oblong-clavate; stylus minute and subulate or sometimes a small disc-like process: underleaves distant or contiguous, orbicular or reniform, strongly reflexed, at least at the apex, bifid about one-fourth with obtuse lobes and sinus, auriculate at base: leaf-cells of lobe rather thick-walled, trigones and intermediate thickenings becoming prominent towards the middle; discolored cells usually absent, sometimes occurring on the leaves of ultimate branchlets: ♀ inflorescence terminal on a short, lateral branch; bracts in about three pairs, deeply and unequally bifid, the lobe ovate, acuminate, entire, sinuous or very sparingly dentate on the margin, lobule subulate, often distorted or uncinate at the acuminate apex, revolute on the margins, bearing on the inner side towards the base an indis-

tinct laciniate lobe or cluster of cilia (stylus); bracteole (at least the innermost one) connate on both sides with bracts, ovate, bifid one-third or more with narrow subulate, acuminate lobes and narrow sinus, margins revolute and entire above, dentate or ciliate toward base; perianth exserted one-third or more, ovate or oblong, gradually narrowed into a short broad beak, concave antically, compressed on the sides and deeply one-keeled postically: antheridial spike oval, occupying a short lateral branch, bracts in several pairs.

Stems 0·30^{mm} in diameter; lobes of leaves 1·20^{mm} long, 0·85^{mm} wide, lobules 0·20^{mm} long, 0·15^{mm} wide; underleaves 0·68^{mm} long, 0·85^{mm} wide; lobes of branch-leaves 0·60^{mm} long, 0·35^{mm} wide; branch-underleaves 0·25^{mm} long and wide; leaf-cells from edge of lobe 0·014^{mm}, from middle 0·023^{mm} in diameter, and from base 0·035^{mm} long, 0·023^{mm} wide; bract I, lobe 2·00^{mm} long, 0·75^{mm} wide; lobule 0·75^{mm} long, 0·15^{mm} wide; bracteole I, 1·35^{mm} long, 0·60^{mm} wide; bract II, lobe 1·25^{mm} long, 0·65^{mm} wide, lobule 0·55^{mm} long, 0·10^{mm} wide; bracteole II, 0·85^{mm} long, 0·30^{mm} wide; perianth 2·50^{mm} long, 1·00^{mm} wide.

On rocks and trees, from Alaska to northern California. Distributed in Can. Hep. *n. 3* (as *F. Asagrayana*, var.), *n. 4* (as *F. Asagrayana*, var. *Californica*), and *n. 5* (in part).

The determination of this species is based on Sullivant's description and on drawings in his herbarium: the type specimen was sent by him to Gottsche, together with the rest of the Wilkes' hepatics, and is presumably in Berlin. *F. Nisquallensis* has frequently been confused with *F. Tamarisci*.

13. **Frullania Asagrayana** Mont., Ann. des Sc. Nat., II. xviii: 14. 1842 (footnote).

Plate XI.

Dioicous: plants growing in depressed or pendulous tufts, reddish-brown or more rarely paler and greenish: stems once or twice pinnate: leaves imbricated, the lobes ovate, arching over the stem and cordate at base, rounded or obtuse at the decurved apex, entire; lobule separated from the stem by about half its width, obovoid-clavate, contracted toward base; stylus a suborbicular disc-like process bearing on its margin one or two minute cilia or running out into one or two acute points: underleaves distant, orbicular-ovate, plane or rarely reflexed at the apex, bifid less than half with obtuse lobes and sinus, sometimes appendiculate or slightly auriculate at base: leaf-cells of lobe thick-walled, trigones and intermediate thickenings becoming more conspicuous toward the middle

and base; discolored cells usually forming a long, distinct, median line, rarely obsolete: ♀ inflorescence terminal on a short branch; bracts in two or three pairs, bifid to or beyond the middle, the lobe ovate, acute, entire or sparingly dentate, becoming broader and more obtuse away from the perianth, lobule narrowly ovate or lanceolate, acuminate, usually revolute on the margins, bearing at the base on the inner edge a more or less distinct, variously toothed or laciniate segment or stylus, otherwise entire; bracteole free or connate on one side, ovate, bifid to or beyond the middle with subulate acuminate lobes and pointed sinus, margin usually bearing at the base on each side a variously toothed or laciniate segment, otherwise entire; perianth exserted beyond the middle, oval or obovate, narrowed into a rather short beak, somewhat compressed on the sides and with a deep postical keel, smooth: ♂ spike oval, occupying a short lateral branch, bracts in several pairs (six to ten).

Stems 0·15^{mm} in diameter; lobes of leaves 0·70^{mm} long, 0·50^{mm} wide; lobules 0·25^{mm} long, 0·17^{mm} wide; underleaves 0·35^{mm} long and wide; lobes of branch leaves 0·50^{mm} long, 0·35^{mm} wide; branch-underleaves 0·25^{mm} long, 0·15^{mm} wide; leaf-cells at edge of lobe 0·014^{mm}, in the middle 0·017^{mm} in diameter and at the base 0·028^{mm} long, 0·018^{mm} wide; bracts I, lobe 1·50^{mm} long, 0·70^{mm} wide, lobule 0·85^{mm} long, 0·25^{mm} wide; bracteole I, 1·20^{mm} long, 0·50^{mm} wide; bract II, lobe 0·95^{mm} long, 0·60^{mm} wide; lobule 0·50^{mm} long, 0·15^{mm} wide; bracteole II, 0·70^{mm} long, 0·25^{mm} wide; perianth 1·85^{mm} long, 0·90^{mm} wide.

On rocks, on bark of trees, or pendulous from small branches: from Newfoundland to Georgia and west to Wisconsin. Common in the Eastern States, especially in hilly or mountainous regions. Distributed in Musc. Alleg. *n. 266*, in Hep. Bor.-Amer. *n. 107*, in Hep. Amer. *n. 7*, and in Can. Hep. *n. 2*.

14. **Frullania Tamarisci** (L) Dumort., Recueil d'Obs. sur les Jung., 13. 1835.

Jungermannia Tamarisci L., Species plantarum, 1134. 1753 (Ed. I).

Frullania major Raddi, Mem. di Matem. e di Fiscia della Soc. Ital. della Sci. (Modena), xviii: 20, *pl. 2.* 1820.

Jubula Tamarisci Dumort., Comm. Bot., 112. 1822.

Plate XII. figs. 1–10.

Dioicous: plants growing in depressed tufts, reddish-brown, rarely tinged with green: stems mostly bipinnate: leaves imbricated, the lobe ovate-orbicular, arching over the stem and deeply cordate at

base, obtuse, apiculate or acute at the decurved apex (on ultimate branches sometime acuminate); lobule separated from the stem by about half its width, subparallel with the stem, short-clavate, contracted toward base; stylus a small disc-like or strongly crispate process: underleaves distant, orbicular, strongly reflexed at apex and usually on the sides, bifid about one-sixth with a broad, shallow sinus and obtuse or apiculate lobes, crispate-auriculate at base: leaf-cells of lobe thick-walled, trigones and intermediate thickenings becoming more pronounced on passing inward and toward the base; discolored cells usually indistinct, either scattered or in a short median line: ♀ terminal on a short branch; bracts in three or four pairs unequally bifid, the lobe ovate, acute, irregularly dentate or crenate, especially in the upper part, lobule lanceolate, acuminate, revolute on the margins, bearing at the base on the inner side a cluster of fine cilia, otherwise subentire: bracteole free from the bracts, deeply bifid with ovate-lanceolate, acute, irregularly dentate or laciniate lobes and narrow sinus, margins ciliate at base. perianth exserted one-third or more, oblong, narrowed into a short beak, postically strongly one-keeled, smooth: ♂ spike oval, borne on a short lateral branch, bracts in several pairs.

Stems $0{\cdot}20^{mm}$ in diameter; lobes of leaves $0{\cdot}80^{mm}$ long, $0{\cdot}75^{mm}$ wide, lobules $0{\cdot}25^{mm}$ long, $0{\cdot}10^{mm}$ wide; underleaves $0{\cdot}45^{mm}$ long, $0{\cdot}40^{mm}$ wide; lobes of branch-leaves $0{\cdot}35^{mm}$ long, $0{\cdot}25^{mm}$ wide; branch-underleaves $0{\cdot}18^{mm}$ long, $0{\cdot}15^{mm}$ wide; leaf-cells from edge of lobe $0{\cdot}012^{mm}$, from middle $0{\cdot}019^{mm}$ in diameter, and from base $0{\cdot}038^{mm}$ long, $0{\cdot}022^{mm}$ wide; bract I, lobe $1{\cdot}20^{mm}$ long, $0{\cdot}60^{mm}$ wide, lobule $0{\cdot}75^{mm}$ long, $0{\cdot}30^{mm}$ wide, bracteole I, $0{\cdot}80^{mm}$ long, $0{\cdot}60^{mm}$ wide; bract II, lobe $1{\cdot}10^{mm}$ long, $0{\cdot}55^{mm}$ wide, lobule $0{\cdot}60^{mm}$ long, $0{\cdot}24^{mm}$ wide; bracteole II, $0{\cdot}90^{mm}$ long, $0{\cdot}45^{mm}$ wide; perianth $2{\cdot}15^{mm}$ long, $0{\cdot}90^{mm}$ wide.

On rock and trees; Miquelon Island (Delamare): Newfoundland (Waghorne): Blackstone, Rhode Island (Bennett). "Vancouver and Orcas Islands, *Lyall.* Collected also on the N. W. coast by *Menzies* and *Douglas.*"[1] Apparently rare, but probably more abundant in the far north.

In the absence of fertile American material the above descriptions of involucre and perianth are drawn from Swedish plants collected by Dr. Arnell. The Rhode Island specimens which I have had an opportunity of examining are very fragmentary, but are apparently referable to this species.

[1] Mitten, Jour. Linn. Soc., viii: 53. 1865. It is probable that these specimens from the Pacific Coast would now be referred to other species.

15. **Frullania Californica** (Aust.).

Frullania Asagrayana, var. *Californica* Aust. in Underwood, Bull. Ill. State Lab. Nat. Hist., ii: 67. 1884 (in part).

Frullania Asagrayana, var. *Californica* Aust. (emend.), Howe, Erythea, ii: 98. 1894.

Frullania Asagrayana, var. *alsophila* Howe, l. c., ii: 99. 1894.

Frullania Tamarisci Bolander, Catalogue of the Plants growing in the vicinity of San Francisco. 1870 (not (L.) Dum.).

Plate XII. figs. 11–22.

Dioicous: plants closely appressed to matrix or growing in wide depressed tufts, green, varying to brownish-red: stems once to thrice pinnate, often irregularly so: leaves subimbricated, the lobe orbicular, arching over the stem and cordate at base, rounded and more or less decurved at the apex, entire; lobule separated from the stem by less than half its width, obovate-clavate; stylus a minute subulate or disc-like process: underleaves orbicular, plane or slightly reflexed on one or both sides toward the base, bifid about one-third with obtuse or subacute lobes and sinus, margin entire, sometimes slightly auriculate at base; leaf-cells rather thick-walled, trigones inconspicuous and intermediate thickenings scanty; discolored cells wanting or few in number, scattered or more rarely in a short median line: ♀ inflorescence terminal on a short branch; bracts in two or three pairs, unequally bifid, the lobe ovate or ovate-lanceolate, acute, entire, lobule lanceolate or subulate, acuminate, margin more or less reflexed, bearing on the inner side at the base a laciniate lobe-like segment or stylus, otherwise entire, bracteole connate on one side with bract, ovate, bifid to about the middle with lanceolate acuminate lobes and acute sinus, bearing toward the base on each side a distinct usually laciniate or ciliate segment, otherwise entire; both bracts and bracteoles becoming smaller and simpler on receding from the perianth; perianth about half exserted, compressed on the sides, oval, narrowed into a short beak, deeply one-keeled postically, smooth; ♂ spike on a short lateral branch, globose, bracts in about two pairs.

Stems 0·15^{mm} in diameter; lobes of leaves 0·50^{mm} long, 0·45^{mm} wide, lobules 0·17^{mm} long, 0·09^{mm} wide; underleaves 0·22^{mm} long, 0·25^{mm} wide; lobes of branch-leaves 0·22^{mm} long, 0·17^{mm} wide; branch-underleaves 0·12^{mm} long, 0·09^{mm} wide; leaf-cells at edge of lobe 0·010^{mm} in the middle, 0·014^{mm} in diameter, and at the base 0·030^{mm} long, 0·022^{mm} wide; bract I, lobe 1·40^{mm} long, 0·55^{mm} wide, lobule 0·75^{mm} long, 0·25^{mm} wide; bracteole I, 1·00^{mm} long, 0·50^{mm} wide; bract II, lobe 0·90^{mm} long, 0·50^{mm} wide, lobule 0·45^{mm} long,

0·20^{mm} wide; bracteole II, 0·80^{mm} long, 0·50^{mm} wide; perianth 1·70^{mm} long, 0·80^{mm} wide.

On rocks and trees: British Columbia to California. Distributed (as *F. Nisquallensis*) in Hep. Bor.-Amer. *n. 108* (in part), in Hep. Amer. *n. 102* (as *F. Asagrayana*, var. *Californica*) and *n. 148* (as *F. Nisquallensis*), and (also as *F. Nisquallensis*) in Can. Hep. *n. 5* (in part).

The specimens distributed in Hep. Bor.-Amer., which we may consider the type of Austin's *F. Asagrayana*, var. *Californica*, are a mixture of this and the next species, and it seems allowable to retain the name "*Californica*" for the present series of forms.

16. **Frullania Franciscana** Howe, Erythea, ii: 99. *pl. 2.* 1894.

Frullania Asagrayana, var *Californica* Aust. in Underwood, Bull. Illinois State Lab. Nat. Hist, ii: 67. 1884 (in part).

Frullania unciflora, var. *Californica* Gottsche in Bolander: Catalogue of the plants growing in the vicinity of San Francisco. 1870.

Plate XIII. figs. 1–8.

Dioicous: plants appressed to matrix or growing in wide depressed tufts, reddish-brown, varying to greenish; stems mostly bipinnate: leaves imbricated, the lobes ovate, arching over the stem and cordate at base, rounded, obtuse or apiculate at the decurved apex, entire; lobule separated from the stem by about its own width, short-clavate; stylus minute: underleaves distant, plane, rhombic-ovate, bifid about one-third with obtuse lobes and narrow sinus, margins usually bluntly unidentate at about the middle, neither auriculate nor appendiculate at base: leaf-cells of lobe rather thick-walled, trigones and intermediate thickenings becoming more conspicuous toward the middle and the base; discolored cells usually in a short median line, sometimes obsolete: ♀ inflorescence terminal on a short branch; bracts in about three pairs, unequally bifid, the lobe ovate, acute or acuminate-apiculate, ciliate at antical base, otherwise entire; lobule ovate or lanceolate, acute, bearing a cluster of cilia toward base, otherwise entire; bracteole connate on one side with bract, ovate, bifid about one half with lanceolate, acuminate lobes and narrow sinus, ciliate at base, otherwise entire; perianth oblong-obovate, abruptly short-rostrate, compressed on sides and with a deep postical keel, smooth.

Stems 0·17^{mm} in diameter: lobes of leaves 0·95^{mm} long, 0·70^{mm} wide, lobules 0·25^{mm} long, 0·12^{mm} wide; underleaves 0·40^{mm} long, 0·35^{mm} wide; lobes of branch-leaves 0·35^{mm} long, 0·25^{mm} wide;

branch-underleaves 0·17^{mm} long, 0·15^{mm} wide ; leaf-cells at edge of lobe 0·014^{mm} in the middle 0·019^{mm} in diameter and at the base 0·035^{mm} long, 0·023^{mm} wide ; bract I, lobe 1·50^{mm} long, 0·75^{mm} wide, lobule 0·60^{mm} long, 0·25^{mm} wide ; bracteole I, 1·35^{mm} long, 0·60^{mm} wide ; bract II, lobe 1·25^{mm} long, 0·50^{mm} wide, lobule 0·40^{mm} long, 0·20^{mm} wide ; bracteole II, 1·00^{mm} long, 0·50^{mm} wide ; perianth 2·20^{mm} long, 1·00^{mm} wide.

On trees ; California. Distributed (as *F. Nisquallensis*) in Hep. Bor.-Amer. *n. 108* (in part).

The plants of the present group have long been a puzzle to American hepaticologists ; most of them are species of wide range, they vary greatly according to environment and are apparently connected with one another by transitional forms. In sterile material, moreover, the essential characters of a species are often so slightly developed as to make determination difficult if not impossible, and the same thing is true, though in a far less degree, of antheridial material. In the eastern parts of the United States the only common representative is *Frullania Asagrayana*, a plant which frequently assumes forms very unlike the specimens originally described by Montagne: the most important differences brought out in this description between our plant and *F. Tamarisci* are in the underleaves, which are said to be plane, and in the perichætial bracts, which are said to be subentire. Neither of these characters is constant ; the underleaves may be reflexed, and the bracts are sometimes dentate. The underleaves, nevertheless, do afford us a second and more important distinction in the basal auricles or lobes sometimes found in *F. Asagrayana ;* these are never crispate as in the constant and well developed auricles of *F. Tamarisci.* The stylus of *F. Asagrayana* is unusually large, being sometimes as long as the lobule. A somewhat similar stylus is sometimes found in other species of this group, but it is always smaller than in *F. Asagrayana ;* and, in *F. Tamarisci*, it is more or less crispate like the auricles of the underleaves. In *F. Asagrayana*, finally, the lobules of the perichætial bracts and usually also the bracteoles bear at the base more or less distinct, laciniate segments : these reappear in the western *F. Californica*, but are unlike the equivalent structures found in our other species.

In the far north the closely related *F. Tamarisci*, which is abundant in Europe, apparently becomes more common, sometimes occurring in company with *F. Asagrayana.* The most important points of difference between the two are indicated above, but the

involucres furnish one or two additional ones : in *F. Tamarisci* bracts and bracteoles are relatively broader and the distinct stylus of *F. Asagrayana* is replaced by a cluster of fine cilia. The leaves of *F. Tamarisci*, also, are usually somewhat pointed, while the median row of discolored cells is rarely distinct.

As we go westward *F. Nisquallensis*, another close ally of *F. Tamarisci*, makes its appearance. The leaves of this species are still more sharply pointed, and the reflexed underleaves show basal auricles which are not strongly crispate as in *F. Tamarisci*. The involucres, also, provide us with important differences; in *F. Nisquallensis*, the bracteoles, at least the innermost, are connate on both sides with the adjacent bracts, and the lobes of the latter are narrow, acuminate and subentire.

In addition to *F. Nisquallensis*, we have in the west the plants which have been known as *F. Asagrayana*, var. *Californica*. The confusion in regard to these plants has been partially cleared up by Mr. Howe, but it seems best to go still farther than he has done and to recognize two distinct species, instead of trying to retain one of them as a variety of *F. Asagrayana*. The first of these species, *F. Franciscana*, resembles the eastern plant in its plane underleaves and in the median line of discolored cells in its lobes ; but the latter is a less striking feature than in *F. Asagrayana* and the underleaves are different in shape and never auriculate at the base. The stylus, too, is usually reduced to a minute subulate process and, in the perichætial bracts, is replaced by a cluster of cilia, a similar cluster being found also at the antical base of the lobe.

The second of these two species, *F. Californica*, is usually more slender than any of our other *Thiopsiellæ* and its less imbricated leaves give it a somewhat looser appearance. In the involucre, the bracts rapidly increase in size ; so that, while the outer ones are often smaller than the corresponding ones in *F. Asagrayana*, the innermost bracts are larger : the bases of bracts and of bracteoles are much as in the eastern species, but the lobes of the bracts are proportionately narrower. The underleaves are variable ; in rare cases they are slightly auriculate at the base, while their margins are either plane or slightly reflexed on one or both sides near the base, never at the apex. The stylus of the leaves is minute, very much as in *F. Franciscana*, from which the present species differs in the usual absence of the median line of discolored cells, in the shape of its underleaves, and in the characters of its perichætial bracts and bracteoles.

SUBGENUS V.—**DIASTOLOBA** Spruce.

Key to the Species.

Bracts and bracteoles (at least those of the innermost row) strikingly dentate or spinose.

Lobes of leaves marked by a line of discolored cells; lobules of bracts with a distinct segment or stylus on inner edge. 17. *F. Selwyniana.*

Lobes of leaves without discolored cells; stylus of bracts not distinct. 19. *F. Donnellii.*

Bracts and bracteoles entire or nearly so.

Lobules of leaves parallel with the stem. 18. *F. Kunzei.*

Lobules of leaves widely spreading from the stem. 20. *F. Caroliniana.*

17. **Frullania Selwyniana** Pearson, List of Canadian Hepaticæ, *1. pl. 1.* 1890.

Frullania Sullivantiæ Aust., Bull. Torrey Bot. Club, iii: 16. 1872 (not *F. Sullivantii* Aust.).

Frullania fragilifolia Aust., l. c., vi: 301. 1879 (not Tayl.).

PLATE XIII. figs. 9–17.

Autoicous: plants appressed to matrix, reddish-brown or purplish: stems irregularly pinnate: leaves imbricated, the lobe ovate, arching over the stem and cordate at base, somewhat decurved at the rounded apex, entire; lobule close to the stem and subparallel with it, short-clavate; stylus minute, subulate; underleaves distant, rhombic-oval, bifid about one-third with obtuse lobes and sinus, entire or unidentate on the sides; leaf-cells of lobe thick-walled, trigones inconspicuous except in the middle and toward the base, intermediate thickenings scanty, discolored cells in a median line: ♀ inflorescence terminal on the stem or a main branch; bracts in about three pairs, unequally bifid, the lobe ovate, acute (becoming obtuse as we recede from the perianth), irregularly dentate, lobule narrower than the lobe, ovate, acute, irregularly ciliate-dentate and bearing a distinct, usually dentate segment or stylus below the middle of the inner edge; bracteole free, broadly ovate, bifid to below the middle, with acute lobes and sinus, irregularly ciliate-dentate (becoming simply dentate on receding from the perianth); perianth about a third exserted, obcuneate, compressed on the sides, and with a strong postical keel, abruptly narrowed into a short, broad beak, minutely setulose at the

mouth : ♂ spike globose, occupying the extremity of a short lateral branch near the perianth, bracts in about two pairs.

Stems 0·13^{mm} in diameter ; lobes of leaves 0·50^{mm} long, 0·45^{mm} wide, lobules 0·23^{mm} long, 0·14^{mm} wide ; underleaves 0·25^{mm} long and wide ; lobes of branch-leaves 0·35^{mm} long, 0·30^{mm} wide; branch-underleaves 0·18^{mm} long, 0·14^{mm} wide ; leaf-cells at edge of lobe 0·015^{mm}, in the middle 0·018^{mm} in diameter, at the base 0·030^{mm} long 0·023^{mm} wide ; bract I, lobe 1.10^{mm} long, 0·50^{mm} wide, lobule 0·95^{mm} long, 0·40^{mm} wide; bracteole I, 0·85^{mm} long, 0·70^{mm} wide; bract II, lobe 0·90^{mm} long, 0·85^{mm} wide, lobule 0·75^{mm} long, 0·25^{mm} wide ; bracteole II, 0·70^{mm} long, 0·40^{mm} wide; perianth 1·25^{mm} long, 0·90^{mm} wide.

On bark of trees (mostly the white cedar); near Urbana, Ohio (Sullivant, Miss Biddlecome) : Campaign County, Ohio (Werner): Ste. Anne's River, Gaspé, Canada (Macoun). Distributed in Hep. Amer. *n. 176.*

Austin was apparently familiar with the characters of this distinct little species, for he has described them clearly and fully under his *F. Sullivantiæ;* but, strangely enough, he afterwards considered them too unimportant to separate our plant from the European *F. fragilifolia.* In a sterile condition, the two species certainly resemble each other closely ; both are reddish in color and branch in about the same way and both show discolored cells in their leaves. In *F. fragilifolia*, however, the stems are a little more slender than in *F. Selwyniana*, the underleaves are narrower, and the discolored cells are usually irregularly scattered instead of being arranged in a more or less distinct line or group in the middle of the lobe. When inflorescence or perianths are present, *F. Selwyniana* can be at once distinguished from the European plant by its antheridial spikes borne close to the involucre ; its perianth, too, is less exserted, its innermost bracts are acute, and its bracteoles are free. *F. Selwyniana* is our only autoicous species with discolored cells in its leaves. I have retained for this species the name recently given to it by Mr. Pearson, Austin's older name being too like *F. Sullivantii.*

18. **Frullania Kunzei** Lehm. et Lindenb. in G. L. et N. Syn. Hep., 449. 1845.

Jungermannia Kunzei Lehm. et Lindenb. in Lehmann, Pugillus vi: 50. 1834.

Frullania Drummondii Tayl., Lond. Jour. Bot., v: 401. 1846.

PLATE XIV. figs. 1–16.

Autoicous: plants closely appressed to matrix, reddish-brown, varying to deep blackish-purple in more exposed situations: sterile

stems regularly once or twice pinnate, fertile stems more irregularly pinnate: leaves contiguous or imbricated, the lobe orbicular-ovate, arching over the stem but not cordate at base, mostly plane at the rounded apex, entire: lobule close to the stem and subparallel with it, short-clavate; stylus minute: underleaves distant, obovate, plane, bifid about one third with obtuse or subacute lobes and sinus, entire: leaf-cells of lobe thick-walled with inconspicuous trigones and no intermediate thickenings: ♀ inflorescence terminal on the stem or a main branch, bracts in three or four pairs, unequally bifid, the lobe ovate or oblong, rounded or obtuse and often apiculate at the apex, entire; lobule narrower, ovate, subacute, bearing a minute tooth or stylus on the inner edge near the base, otherwise subentire; bracteole free or connate on one side, ovate, bifid to about the middle with subacute lobes and sinus, entire or slightly sinuous-dentate; perianth more than half-exserted, compressed on the sides and strongly one-keeled postically, oblong, abruptly narrowed into a short beak, setulose at the mouth: ♂ spike globose, terminal on a short branch at some distance from the involucre, bracts in about two pairs.

Stems 0·10^{mm} in diameter; lobes of leaves 0·45^{mm} long, 0·35^{mm} wide, lobules 0·18^{mm} long, 0·10^{mm} wide; underleaves 0·20^{mm} long, 0·17^{mm} wide; lobes of branch-leaves 0·35^{mm} long, 0·25^{mm} wide; branch-underleaves 0·17^{mm} long, 0·10^{mm} wide; leaf-cells from edge of lobe 0·012^{mm}, from middle 0·016^{mm} in diameter, and from base 0·035^{mm} long, 0·022^{mm} wide; bracts I, lobe 0·85^{mm} long, 0·45^{mm} wide, lobule 0·80^{mm} long 0·30^{mm} wide; bracteole I, 0·85^{mm} long, 0·50^{mm} wide; bract II, lobe 0·70^{mm} long, 0·45^{mm} wide, lobule 0·50^{mm} long, 0·25^{mm} wide; bracteole II, 0·50^{mm} long, 0·35^{mm} wide; perianth 1·25^{mm} long, 0·75^{mm} wide.

On bark of trees, or sometimes creeping over lichens; Florida to Louisiana. Distributed in Hep. Bor.-Amer. *n. 105d*, and in Hep. Amer. *n. 101.*

Frullania Kunzei was first described from Cuban material, but does not seem to have been collected very often in the West Indies; in our Gulf States, on the contrary, it is apparently not uncommon. It is most closely related to the following species, *F. Donnellii*, but also bears some resemblance to *F. Selwyniana.* From this latter species it differs in its more regularly pinnate stems, in its narrower, less convex and homogeneous leaves, which are not cordate at the base, in its more exserted perianth with longer setulæ at the mouth, and in its entire bracts.

19. **Frullania Donnellii** Aust., Bull. Torrey Bot. Club, iv: 301. 1879.

PLATE XIV. figs. 17–29.

Autoicous: plants closely appressed to matrix, reddish-brown: sterile stems regularly once or twice pinnate, fertile stems more irregularly pinnate: leaves contiguous or imbricated, the lobe orbicular-ovate, arching over the stem but not cordate at base, plane or nearly so at the rounded apex, entire; lobule separated from the stem by a little less than its width, subparallel with it or slightly oblique, short-clavate; stylus minute: underleaves distant, oblong-obovate, plane, bifid about one third with obtuse or subacute lobes and sinus, entire: leaf-cells of lobe thick-walled with inconspicuous trigones and no intermediate thickenings: ♀ inflorescence terminal on the stem or a main branch; bracts in two or three pairs, subequally bifid, the lobe ovate, acuminate, sharply and irregularly incised-dentate, lobule similar to the lobe but usually still more toothed, stylus not distinct; bracteole free, bifid to or beyond the middle with segments like the lobules; bracts and bracteoles becoming rapidly smaller and less toothed on receding from the perianth; perianth about half-exserted, compressed on the sides and strongly one-keeled postically, oblong, abruptly narrowed into a short beak, setulose at the mouth; ♂ spike globose, occupying a short branch close to the involucre, bracts in about two pairs.

Stems 0·10^{mm} in diameter; lobes of leaves 0·60^{mm} long and wide; lobules 0·19^{mm} long, 0·12^{mm} wide; underleaves 0·30^{mm} long, 0·25^{mm} wide; lobes of branch-leaves 0·30^{mm} long, 0·25^{mm} wide; branch-underleaves 0·20^{mm} long, 0·10^{mm} wide; leaf-cells at edge of lobe 0·012^{mm}, in the middle 0·018^{mm} in diameter and at base 0·035^{mm} long, 0·018^{mm} wide; bract I, lobe 0·90^{mm} long, 0·55^{mm} wide, lobule 0·90^{mm} long, 0·45^{mm} wide; bracteole I, 0·70^{mm} long and wide; bract II, lobe 0·75^{mm} long, 0·45^{mm} wide, lobule 0·60^{mm} long, 0·35^{mm} wide; bracteole II, 0·70^{mm} long, 0·55^{mm} wide; perianth 1·20^{mm} long, 0·70^{mm} wide.

On trees; East Florida (J. Donnell Smith): Eustis, Florida (Underwood): Monticello, Florida (Lighthipe).

F. Donnellii seems to be a rare species, but, as sterile material is usually indistinguishable from *F. Kunzei*, it has probably been overlooked. The main difference between the two species is to be found in the perichætial bracts: in *F. Kunzei* these are entire or nearly so, while in *F. Donnellii* the innermost ones at least are strongly incised-dentate.

The first three species which are here placed in *Diastoloba* are in some respects intermediate between that subgenus and *Thiopsiella*, agreeing with the latter mainly in having their lobules parallel with

the stem. Still, it has seemed better on the whole to group them with *F. Caroliniana*, as they agree with it in the following important points: (1) the plane underleaves, (2) the autoicous inflorescence, and (3) the position of the ♀ flowers.

20. **Frullania Caroliniana** Sulliv., Musc. Alleg. *n. 270.* 1846. Amer. Jour. Sci. and Arts, II. i: 74. 1846.

Frullania brunnea Aust., Hep. Bor.-Amer., *n. 105e.* 1875 (not Spreng.).

Plate XV.

Autoicous: plants closely appressed to matrix, varying in color from yellowish-green to reddish-brown; sterile stems mostly bipinnate, fertile stems more irregularly branched: leaves closely imbricated, the lobe ovate, arching over the stem but not cordate at base, rounded and slightly decurved at the apex, entire; lobule distant from the stem and spreading at a wide angle (30°–40°), short-clavate; stylus a small, obliquely spreading triangular process: underleaves contiguous or imbricated, orbicular, plane, bifid about one-half with obtuse or subacute lobes and sinus, entire or vaguely unidentate on the sides; branch-underleaves much narrower and with sharper points: leaf-cells of lobes sometimes thick-walled with inconspicuous trigones, sometimes thinner walled with conspicuous trigones and occasional intermediate thickenings: ♀ inflorescence terminal on the stem or a main branch; bracts in three or four pairs, unequally bifid, the lobe ovate, obtuse or apiculate at the apex, entire; lobule shorter and narrower, ovate, subacute, bearing on the inner edge near the base a distinct tooth-like segment or stylus, otherwise entire; bracteole free or connate on one side with bract, bifid about one-third with acute lobes and sinus, entire or nearly so; perianth exserted about one-third, obcuneate, abruptly narrowed into a short, setulose beak, compressed on the sides and strongly unicarinate postically; ♂ spike globose, occupying a short lateral branch near the ♀ inflorescence, bracts in one or two pairs.

Stems $0{\cdot}10^{mm}$ in diameter; lobes of leaves $0{\cdot}70^{mm}$ long, $0{\cdot}80^{mm}$ wide, lobule $0{\cdot}20^{mm}$ long, $0{\cdot}10^{mm}$ wide; underleaves $0{\cdot}40^{mm}$ long, $0{\cdot}30^{mm}$ wide; lobes of branch-leaves $0{\cdot}30^{mm}$ long, $0{\cdot}40^{mm}$ wide; branch-underleaves $0{\cdot}20^{mm}$ long and wide; leaf-cells from edge of lobe $0{\cdot}017^{mm}$, from middle $0{\cdot}018^{mm}$ in diameter, and from base $0{\cdot}038^{mm}$ long, $0{\cdot}023^{mm}$ wide; bract I, lobe $1{\cdot}25^{mm}$ long, $0{\cdot}75^{mm}$ wide, lobule $0{\cdot}80^{mm}$ long, $0{\cdot}40^{mm}$ wide; bracteole I, $0{\cdot}80^{mm}$ long, $0{\cdot}40^{mm}$ wide, bract II, lobe $0{\cdot}90^{mm}$ long, $0{\cdot}57^{mm}$ wide, lobule $0{\cdot}60^{mm}$ long, $0{\cdot}30^{mm}$ wide, bracteole II, $0{\cdot}55^{mm}$ long, 0.35^{mm} wide; perianth $1{\cdot}50^{mm}$ long, $1{\cdot}20^{mm}$ wide.

On trees; Florida to Louisiana. Distributed in Musc. Alleg. *n. 270*, in Hep. Bor.-Amer. *n. 105e* (as *F. brunnea*), and in Hep. Amer. *n. 84* (as *F. brunnea*).

F. Caroliniana was referred by Austin to *F. brunnea*, a plant found in southern Africa. Herr Stephani has kindly sent me a specimen of this species from the type locality and I find it to differ from our plant in the following points:—the leaves are usually minutely apiculate, especially on the branches; the lobules spread still more widely, often forming more than a right angle with the stem; the stylus is smaller; the underleaves are sharply spinose-dentate, those of the branches being sometimes almost laciniate. *F. Caroliniana* is easily distinguished from all our other species by the distant and widely spreading lobules of its leaves.

Incompletely known Species.

21. **Frullania Chilcootiensis** Steph., Engler's bot. Jahrb., viii: 98. 1886.

Dioicous: plants growing on bark with other hepaticæ, brownish: stems filiform, simple, 3–4^{mm} long; leaves remote, the lobe broadly ovate, obtuse, concave, decurved at the apex, entire, arching over the stem; lobule a third as large as the lobe, galeate, constricted near the mouth, close to the stem or often obliquely incumbent; stylus large, triangular-lanceolate, spreading: underleaves spreading, cuneate-obovate, bifid to about the middle, with a narrow obtuse sinus and connivent, obtuse lobes, angled or obtusely unidentate on the sides; leaf-cells uniformly thickened, 0·010^{mm} in diameter: perichætial bracts in about two pairs, those of the innermost pair double the size of the stem-leaves, spreading, unequally bifid, the lobe oblong-ovate, obtuse, lobule half as broad as the lobe, acute, with a long cilium or stylus above the middle of the inner edge; bracteole nearly as large as bracts, oblong, bifid about one-third with an open obtuse sinus and subacute lobes: perianth and ♂ spike unknown.

On bark; Chilcoot, Alaska (Krause).

I have been unable to obtain specimens of this very minute species and have compiled the above account of the plant from the original description, aided by drawings and notes kindly sent me by Herr Stephani. The plant is apparently a *Trachycolea*.

22. **Frullania Wrightii** Aust., Bull. Torrey Bot. Club, iii: 15. 1872

Dioicous: plants brownish: stems irregularly pinnate: leaves imbricated, the lobe orbicular, arching over the stem and cordate at

base, decurved at the rounded apex, entire ; lobule close to the stem, galeate, inflated, sometimes more distant and explanate ; stylus minute, subulate : underleaves orbicular-obovate, bifid about one-fourth with obtuse or subacute lobes and sinus, entire or repand-dentate on the margins ; leaf-cells of lobe rather thick-walled with conspicuous trigones and intermediate thickenings; ♀ inflorescence terminal on the stem or a main branch ; bracts in two or three pairs, unequally bifid, the lobe ovate, rounded at the apex, entire, lobule shorter and narrower, acute, bearing a small tooth or stylus on the inner edge below the middle, otherwise entire, bracteole free from the bracts, narrowly ovate, bifid about one-third with acute lobes and sinus, subdentate toward base ; perianth and ♂ plant not seen.

New Mexico (Wright).

Frullania Wrightii, known only from its type specimens, is apparently a form of *F. riparia*. It is impossible to be sure of this, however, until better developed plants are found, as there are slight differences between the two in areolation, underleaves, and involucre.

In conclusion I would express my thanks to Professor Underwood for the loan of his valuable collection of *Frullaniæ*, to Herr Stephani for helpful notes, drawings and specimens, to Dr. Robinson for access to several of Taylor's and Sullivant's types, and to Mr. Howe and others for specimens.

Yale University.

EXPLANATION OF PLATES.

Each species is represented in natural size and with enlarged details: in Plates I and IX–XIV, the leaf-cells are enlarged 255, and the other details 28 diameters; in Plates II–VIII and XV, the leaf-cells are enlarged 290, and the other details 32 diameters.

Plate I.

Frullania arietina Tayl.—Fig. 1. Plant, natural size.—Fig. 2. Part of plant, postical view, showing perianth and hypogynous perigonial bracts.—Fig. 3. Leaf-cells from middle of lobe.—Fig. 4. Bracts and connate bracteole I.—Fig. 5. Bracts and connate bracteole II.—Fig. 6. Transverse section of perianth. All the figures from Florida specimens collected by Mr. Smith.

Frullania Oakesiana Aust.—Fig. 7. Plant, natural size.—Fig. 8. Part of plant, postical view, showing perianth and androecium.—Fig. 9. Part of stem with leaf, antical view.—Fig. 10. Leaf-cells from middle of lobe.—Fig. 11. Bract and connate bracteole I.—Fig. 12. Bract I.—Fig. 13. Bract II.—Fig. 14. Bracteole II.—Fig. 15. Transverse section of perianth. All the figures from specimens collected by the author on Carter Dome, New Hampshire.

Plate II.

Frullania Bolanderi Aust.—Fig. 1 Plants, natural size.—Fig. 2. Part of plant, postical view, showing perianth.—Fig. 3. Part of plant, postical view.—Fig. 4. Part of branch, ending in a flagellum.—Fig. 5. Part of stem, antical view.—Fig. 6. Leaf-cells from middle of lobe.—Fig. 7. Bracts with connate bracteole I.—Fig. 8. Bract and connate bracteole I.—Fig. 9. Same, from another involucre.—Fig. 10. Bract and connate bracteole II, from same involucre as Fig. 9.—Fig. 11. Bract and connate bracteole I.—Fig. 12. Bract I.—Fig. 13. Bract and connate bracteole II.—Fig. 14. Bract II.—Fig. 15. Transverse section of perianth. Figs. 1–3 and 5–8 from Californian specimens collected by Mr. Howe; Figs. 4, 9 and 10 from British Columbian specimens collected by Professor Macoun; and Figs. 11–15 from Californian specimens collected by Bolander.

Plate III.

Frullania inflata Gottsche.—Fig. 1. Plant, natural size.—Fig. 2. Part of plant, postical view, showing perianth and androecium.—Fig. 3. Part of plant, postical view.—Fig. 4. Part of stem, antical view.—Fig. 5. Leaf-cells from middle of lobe.—Figs. 6, 7. Bracts I.—Fig. 8. Bracteole I.—Fig. 9. Bract II.—Fig. 10. Bracteole II.—Figs. 11, 12. Transverse sections of perianths.—Fig. 13. Bract I.—Fig. 14. Bracteole I.—Fig. 15. Bract II.—Fig. 16. Bracteole II.—Figs. 17, 18. Transverse sections of perianths. Figs. 1, 3, 4, and 6–12 from specimens collected by Dr. Underwood at Austin, Texas; Figs. 2, 5, and 13–18 from Hep. Amer. *n. 68.*

Plate IV.

Frullania Catalinæ Evans.—Fig. 1. Plants, natural size.—Fig. 2. Part of plant, postical view, showing perianth and androecium.—Fig. 3. Part of plant, postical view.—

Fig. 4. Part of stem, antical view.—Fig. 5. Leaf-cells from middle of lobe.—Fig. 6. Bract and connate bracteole I.—Fig 7. Bract I.—Fig. 8. Bract and connate bracteole II.—Fig. 9. Bract II.—Fig. 10. Bract and connate bracteole III.—Figs. 11, 12. Transverse sections of perianth. All the figures from the type specimens.

PLATE V.

Frullania riparia Hampe.—Fig. 1. Plants, natural size —Fig. 2. Part of plant, postical view, showing ♀ inflorescence.—Figs. 3, 4. Parts of plants, postical view.—Fig. 5. Part of stem, antical view.—Fig. 6. Leaf-cells from middle of lobe.—Figs. 7, 8. Bracts II.—Fig. 9. Bracteole II.—Fig. 10. Bract III.—Fig. 11. Bracteole III. Figs. 1, 4, and 5 from specimens collected by the author at Trumbull, Connecticut; Figs. 2 and 6–11 from specimens collected by Dr. Underwood at Greencastle, Indiana; and Fig. 3 from specimens collected by Mr. Holzinger near Washington.

PLATE VI.

Frullania squarrosa (R. Bl et Nees) Dumort.—Fig. 1. Plant, natural size.—Fig. 2. Part of plant, postical view, showing perianth —Fig. 3. Part of plant, postical view, showing young ♀ inflorescence.—Fig. 4. Part of stem antical view.—Fig. 5. Leaf-cells from middle of lobe.—Fig. 6. Bracts and connate bracteole I.—Fig. 7. Bract and connate bracteole I.—Fig. 8. Bract and connate bracteole II.—Fig. 9. Transverse section of perianth. Figs. 1, 2, and 5–9 from Florida specimens collected by Dr. Underwood; Figs. 3 and 4 from Tennessee specimens collected by Mr. Ruth.

PLATE VII.

Frullania Brittoniæ Evans.—Fig. 1. Plants, natural size.—Fig. 2. Part of plant, postical view, showing perianth.—Fig. 3. Part of plant, postical view, showing young androecium.—Fig 4. Part of stem, antical view.—Fig. 5. Leaf-cells from middle of lobe.—Figs. 6, 7. Bracts I.—Fig. 8. Bracteole I.—Fig. 9. Bract II.—Fig. 10. Bracteole II.—Fig. 11. Bracteole I, from another involucre.—Fig. 12. Transverse section of perianth. All the figures from specimens collected by the author at Meriden, Connecticut.

Frullania dilatata (L) Dumort.—Fig. 13. Bract I.—Fig. 14. Bracteole I.—Fig. 15. Bracteole II. All the figures from Swedish specimens collected by Dr. Arnell.

PLATE VIII.

Frullania Virginica Gottsche.—Fig. 1. Plants, natural size.—Fig. 2. Part of plant, postical view, showing perianth.—Figs. 3, 4. Parts of plants, postical view.—Fig. 5. Part of stem, antical view.—Fig. 6. Leaf-cells from middle of lobe.—Fig. 7. Bracts and connate bracteole I.—Figs. 8, 9. Bracts II.—Fig. 10. Bracteole II.—Fig. 11. Bract III.—Fig. 12. Bracteole III.—Fig. 13. Bracts and connate bracteole I, from another involucre.—Fig. 14. Transverse section of perianth.—Fig. 15. Bract I.—Fig. 16. Bracteole I.—Fig. 17. Bract II.—Fig. 18. Bracteole II.—Fig. 19. Transverse section of perianth. Figs. 1–3 and 5–14 from specimens collected at Auburn, Alabama, by Dr. Underwood; Figs. 4 and 15–19 from specimens collected at Wilmington, Delaware, by Mr. Commons.

PLATE IX.

Frullania Eboracensis Gottsche.—Fig. 1. Plants, natural size.—Fig. 2. Part of plant, postical view, showing perianth; the innermost bract on the left is abnormal in having its stylus about as large as its lobule.—Fig. 3. Part of stem, antical view.—Fig. 4. Leaf-cells from middle of lobe.—Fig. 5. Bracteole I.—Fig. 6. Transverse section of perianth.—Fig. 7. Bract and connate bracteole I.—Fig. 8. Bract I.—Fig. 9. Bract II.—Fig. 10. Bracteole II.—Fig. 11. Transverse section of perianth. Figs. 1–3 from specimens collected by Dr. Jelliffe at Lake George, New York; Figs. 4–6 from specimens collected by Miss Vail in the Catskills, New York; Figs. 7–11 from specimens collected by Mr. Commons at Wilmington, Delaware.

Frullania plana Sulliv.—Fig. 12. Plant, natural size.—Fig. 13. Part of plant, postical view, showing perianth and androecium.—Fig. 14. Part of stem, antical view.—Fig. 15. Leaf-cells from middle of lobe.—Figs. 16, 17. Bracts I.—Fig. 18. Bracteole I.—Fig. 19. Bract II.—Fig. 20. Bracteole II.—Fig. 21. Transverse section of perianth. All the figures from Hep. Bor.-Amer. *n. 102*.

PLATE X.

Frullania Nisquallensis Sulliv.—Fig. 1. Plant, natural size.—Fig. 2. Part of plant, postical view, showing perianth.—Fig. 3. Part of stem, postical view, underleaves dissected away.—Fig. 4. Part of stem, antical view.—Fig. 5. Leaf-cells from middle of lobe.—Fig. 6. Bracts and connate bracteole I.—Fig. 7. Bract II.—Fig. 8. Bracteole II.—Fig. 9. Bract III.—Fig. 10. Bracteole III.—Fig. 11. Transverse section of perianth. All the figures from specimens collected at Anacortes, Washington, by Mrs. F. K. Sears.

PLATE XI.

Frullania Asagrayana Mont.—Fig. 1. Plant, natural size.—Fig. 2. Part of plant, postical view, showing perianth.—Fig. 3. Part of plant, antical view, showing androecium.—Fig. 4. Part of stem, postical view, underleaves dissected away.—Fig. 5. Leaf-cells from middle of lobe.—Fig. 6. Bract I.—Fig. 7. Bracteole I.—Fig. 8. Bract II.—Fig. 9. Bracteole II.—Fig. 10. Bract III.—Fig. 11. Bracteole III.—Fig. 12. Transverse section of perianth.—Figs. 13, 14. Bracts I.—Fig. 15. Bracteole I.—Figs, 16, 17. Bracts II.—Fig. 18. Bracteole II.—Fig. 19. Subinvolucral leaf.—Fig. 20. Subinvolucral underleaf.—Fig. 21. Bract and connate bracteole I.—Fig. 22. Bract I. Figs. 1–12 from specimens collected by Mrs. Britton on White Top, Virginia; Figs. 13–20 from specimens collected by Mr. Waite at Washington, D. C.; Figs. 21 and 22 from specimens collected by Mr. Ruth at Knoxville, Tennessee.

PLATE XII.

Frullania Tamarisci (L.) Dumort.—Fig. 1. Plant, natural size.—Fig. 2. Part of plant, postical view.—Fig. 3. Part of stem, antical view.—Fig. 4. Leaf-cells from middle of lobe.—Fig. 5. Bract I.—Fig. 6. Bracteole I.—Fig. 7. Bract II.—Fig. 8. Bracteole II.—Fig. 9. Bract III.—Fig. 10. Bracteole III. Figs. 1–4 from Newfoundland specimens collected by Mr. Waghorne; Figs. 5–10 from Swedish specimens collected by Dr. Arnell.

Frullania Californica (Aust.) Evans.—Fig. 11. Plant, natural size.—Fig. 12. Part of plant, postical view, showing perianth.—Fig. 13. Part of stem, antical view.—Fig. 14. Leaf-cells from middle of lobe.—Fig. 15. Bract and connate bracteole I.—Fig. 16. Bract I.—Figs. 17, 18. Bracts II.—Fig. 19. Bracteole II.—Fig. 20. Bract III.—Fig. 21. Bracteole III.—Fig. 22. Transverse section of perianth. All the figures from specimens collected at Seattle, Washington, by Mr. Piper.

Plate XIII.

Frullania Franciscana Howe.—Fig. 1. Plant, natural size.—Fig. 2. Part of plant, postical view, showing perianth.—Fig. 3. Part of stem, antical view.—Fig. 4. Leaf-cells from middle of leaf.—Fig. 5. Bract and connate bracteole I.—Fig. 6. Bract I.—Fig. 7. Bract II.—Fig. 8. Transverse section of perianth. All the figures from Californian specimens collected by Mr. Howe.

Frullania Selwyniana Pearson.—Fig. 9. Plants, natural size.—Fig. 10 Part of plant, postical view, showing perianth and androecium.—Fig. 11. Part of plant, postical view.—Fig. 12. Part of stem, antical view.—Fig. 13. Leaf-cells from middle of lobe.—Fig. 14. Bract I.—Fig. 15. Bracteole I.—Fig. 16. Bract II.—Fig. 17. Transverse section of perianth. All the figures from Ohio specimens: Figs. 9, 10 and 14–17 from specimens collected by Mr. Wilcox; the others from specimens collected by Mr. Werner.

Plate XIV.

Frullania Kunzei Lehm. et Lindenb.—Fig. 1. Plant, natural size.—Fig. 2. Part of plant, postical view, showing perianth, androecia, and ♀ inflorescence.—Fig. 3. Part of stem, antical view.—Fig. 4. Leaf-cells from middle of lobe.—Figs. 5, 6. Bracts I.—Fig. 7. Bracteole I.—Figs. 8, 9. Bracts II.—Fig. 10. Bracteole II.—Fig. 11. Bract III.—Fig. 12. Bracteole III.—Fig. 13. Bract and connate bracteole I.—Fig. 14. Bract I.—Fig. 15. Transverse section of perianth.—Fig. 16. Setulæ from mouth of perianth. All the figures from specimens collected by Dr. Underwood: Figs. 13, 14 and 16 from Florida specimens and the others from specimens collected at Ocean Spring, Mississippi.

Frullania Donnellii Aust.—Fig. 17. Plant, natural size.—Fig. 18. Part of plant, postical view, showing perianth and androecium.—Fig. 19. Part of stem, antical view.—Fig. 20. Leaf-cells from middle of lobe.—Figs. 21, 22. Bracts I.—Fig. 23. Bracteole I.—Figs. 24, 25. Bracts II.—Fig. 26. Bracteole II.—Fig. 27. Bract III.—Fig. 28. Bracteole III.—Fig. 29. Transverse section of perianth. All the figures from specimens collected at Eustis, Florida, by Dr. Underwood.

Plate XV.

Frullania Caroliniana Sulliv.—Fig. 1. Plant, natural size.—Fig. 2. Part of plant, postical view, showing perianth and androecia.—Fig. 3. Part of stem, antical view. Fig. 4. Leaf-cells from middle of lobe.—Fig. 5. Bract and connate bracteole I.—Fig. 6. Bract I.—Figs. 7, 8. Bracts II.—Fig. 9. Bracteole II.—Fig. 10. Bract III.—Fig. 11. Bracteole III.—Fig. 12. Transverse section of perianth. All the figures from specimens collected by Mr. Langlois in Louisiana.

II.—A Study of the family Pectinidæ, with a Revision of the Genera and Subgenera. (Six plates.) By A. E. Verrill.

The classification of the Pectinidæ must, for the present at least, be based mainly upon the characters of the shells, for the soft parts have been carefully studied only in a few of the very numerous species. There is good reason to believe that in some cases good generic characters may be found in the structure of the foot, but this organ is so contractile that alcoholic specimens give but a poor idea of its form in life. The palpi and gills are known to afford important characters in some species, but they have been studied in only a few genera. (See Plates xx, xxi.) But the relations of the shell to the soft parts are so very intimate that the form and structure of the shell may be taken as an expression of the modifications of some of the important internal parts, and therefore must give valid evidence of generic modifications.

In this family the use of shell-characters for generic and subgeneric groups has this great advantage that it will enable us to classify the vast number of fossil species, which are far more numerous than the living ones, and to compare those of successive geological periods, group by group, with each other and with modern groups. In this way we may be better able to trace the lines of evolution. Until the minor modifications of structure, such as characterize subgenera and "sections" of genera in this and other bivalve families, are duly considered, no great progress can be made in the study of their evolution.

It is very essential that students of Mollusca should become impressed with the idea that even the slightest modification of the form or structures of the shell, if persistent, has its meaning, and some distinct value in progressive evolution, whether we may be able to discover it or not. Even the color is often of protective value. For instance, the reddish and brown colors of *Chlamys Islandica* matches the colors of the red nullipore that covers the stony bottoms where it is usually found, and *C. irradians* has generally a gray color, similar to that of the sandy bottoms, which it mostly frequents. Instances of protective coloration in the shells of gastropods are very numerous.

In the Pectinidæ we can appreciate the value of some of the modifications of the shell, on purely mechanical principles. Others are known to be correlated with the habits of the species. Thus the strong radial ribs or corrugations, found on species living in shallow water, serve to give their shells great strength, while the interlockings of the ends of the ribs, either in the form of marginal points or scallops, serve to keep the valves in exact apposition when closed, and therefore compensate for the absence of cardinal teeth. Such corrugations and marginal projections are generally lacking in the deep-sea species that are not exposed to the action of the waves. The special, internal, radial ribs of *Amusium* and allied genera also serve to greatly strengthen the thin, smooth shells of this group and enable the valves to resist the action of the powerful adductor muscle in the act of sudden contraction for the purpose of swimming. In this group, the very compressed, round and polished shell indicates an adaptation to very active swimming habits, for such a shell gives the least friction in the singular manner in which these bivalves swim. Our large native scallop (*C. Clintonius* or *Magellanicus*) has a similar form and is remarkable for its swimming powers, even when of large size.

It seems difficult to explain satisfactorily why *Amusium*, and forms like *C. Clintonius*, should have a simple, thin margin, without interlocking points or scallops, and often with the shell incapable of closing tightly. It is possible that many such simple-edged and gaping shells have descended from those with radial ribs and interlocking scallops, for many of the ancient mesozoic fossil species are thus defended. It is true that most (but not all) of the species that have no radial corrugations, and no marginal scallops, are from deep water, where they are not exposed to the rough action of waves and currents. Still they are, even there, exposed to the attacks of various crabs and fishes, against which strong interlocking valves would be an obvious advantage. It seems probable that the increased lightness of the shell, by facilitating rapid swimming, may more than compensate for the loss of the power of passive resistance. This might well be the case whenever their principal enemies are sluggish animals, like drilling gastropods and voracious starfishes, for actively swimming *Pectens* could easily escape from such enemies, while their heavier and more sendentary relatives, especially those attached either directly or by a strong and persistent byssus, might be unable to escape.

Experience in the extensive cultivation of oysters, on the American

coast, and in other parts of the world, shows that starfishes and the drilling gastropods are by far the most destructive enemies of those bivalves. On our shores vast numbers of drilled oyster shells can be found almost everywhere, but drilled shells of our common scallop (*Chlamys irradians*), which is an active swimmer, are comparatively rare. Therefore it is probable that the gradual loss of radial ribs and corrugations, or their failure to develop in certain genera, is due to natural selection, in consequence of the advantage gained by the lighter shells for swimming purposes, in escaping from these sluggish enemies.

Concentric ribs and undulations, found on some very thin shells, serve to stiffen and strengthen the shell against transverse strains, but they tend, also, to facilitate the tight closing of the valves at the simple and thin margins, for they permit a certain degree of flexibility of the thin shell, parallel with the margin. This kind of closure is very obvious in *Propeamusium* and *Cyclopecten*, which include many small, thin, deep-water forms. In some cases the closure is still farther perfected by a flattened or bevelled margin.

Most members of the family, if not all, form a byssus while young, for attachment, but they release themselves very easily and swim actively away. Many large and thick species seem to lose the habit entirely at maturity, and to rest unattached upon the bottom. But some small and delicate species, although capable of active swimming, appear to live attached much of the time through life. This is the case with *Camptonectes* or *Palliolum vitrea* and some allied deep-water species, which attach themselves to the branches of gorgonians, corals, and hydroids, and thus gain protection from their enemies. The presence of a byssus is, however, consistent with the most active swimming powers. (See remarks under *Cyclopecten*, p. 71).

The extreme inequality of the valves in typical *Pecten* (=*Janira*) is a singular character, of ancient origin, for it was fully developed in many mesozoic species, closely allied to modern forms. It is the more strange, because, in most of the other groups having unequal valves, it is the under, or right, valve that is the flattest, but in true *Pectens* the right valve is strongly convex, while the left or upper valve is flat, or even concave externally, and usually shuts inside the margin of the lower valve like a lid. Both valves are thick and strongly ribbed. Probably this shape is advantageous when the shell is resting upon the bottom, with the lower valve partly buried in the sand and gravel around it, but not attached by a byssus, for

then there would be but little surface presented to the waves. The species of this group usually live in rather shallow water, within the limits of wave-action. It is usual for oysters and other attached forms to have the attached valve deepest. When the shells of these one-sided *Pectens* and others of similar form are dropped into the water they generally sink with the flat valve uppermost, so that this form may be useful in keeping them "right side down," now that they have acquired a structure that requires them to lie on the right side, but this will not explain the first origin of the form, which was probably due to the gradual loss of swimming habits.

These one-sided *Pectens* seem to be rather sessile, as compared with most of the other groups, and certainly the great thickness and weight of the shell, and its special form, do not seem to be adapted to active swimming habits. On the other hand, the byssal organs for attachment are not very well developed, so that the adult shells probably rest upon the bottom unattached, and move about by means of the foot.

That they do not have the swimming habit well developed is also indicated by the unusually tight closure of the valves at the base of the auricles, where the expulsion of the water takes place during the act of swimming, in this family. The right valve is strongly excurved at the byssal notch, and the left valve is strongly bent inward at the corresponding part, so as to fit the marginal notch very completely, leaving at most only a narrow passage for byssal threads. The form of these shells is poorly adapted for swimming, for if currents of water should be expelled in the usual way, from the subauricular margins, the currents would naturally be forced upward, and out of the concave lower valve, and thus the reaction would be strongly downward, so that the shell would not be raised from the bottom.

In those species that are able to rise to the surface and swim actively about, the left or upper valve is always the more convex, and therefore the expelled currents of water must be directed more or less downward, so that the reaction forces the shell upward as well as backward.

In the typical one-sided *Pectens* the foot is pretty well developed, and there is a strongly marked and usually double scar on the left valve, where the pedal muscle is attached, above the scar of the adductor muscle. It is probable, therefore, that they can use the foot effectively for moving about, even when adult.

Remarks on the Ontogeny and Phylogeny of the existing genera of Pectinidæ.

It is not my intention to discuss the special phylogeny of the family, as a whole, at this time, for I have not at hand a sufficient number of the palæozoic genera, in good preservation. This subject has been discussed, to some extent, by Dr. Jackson[1] and others. It is certain that as we go back to the Palæozoic forms, the Pectinidæ, Pernidæ, and other related families gradually converge, and give evidence of a common ancestry. Dr. Jackson has suggested that a *Nucula*-like genus must have been the common ancestral form from which many families of Bivalvia, including Pectinidæ, Aviculidæ, etc., were derived. This view, which has been adopted by Prof. Hyatt,[2] seems to me to lack demonstration and to be improbable, for *Nucula*, although an ancient genus, dating from the Palæozoic, is a rather highly specialized form, as to its foot, palpi, and some other parts, while its hinge-teeth are far more specialized than those of *Cucullæa*, and many other early Palæozoic forms. The veliger-stages of *Mytilus*, *Nucula*, or of *Perna* present more nearly the forms and characters which I believe pertained to the earliest bivalves than any that we yet know from adult forms. But the early veliger-shell of Pectinidæ is similar, and perhaps nearly as primitive in its characters. (See pl. xviii, figs. 1, 12, 13.) In the most ancient allied types, we should, therefore, look for thin, delicate, ovate shells, without any differentiated hinge-teeth. A small internal cartilage, or resilium, was probably coexistent with an external ligament not differentiated from the general perisostracum, and connected directly with the resilium. The latter is formed by the invaginated cells of the primitive shell-gland of the veliger, and the perisostracum by the cells of the general ectodermic membrane, which is continuous with the shell-gland at first; therefore, the two structures must have been continuous, primarily, and probably of simultaneous formation. The greater part of the early bivalves have the resilium[3] and ligament both developed, but in many of the more modern genera, and also in some palæozoic genera, one or the

[1] Dr. R. T. Jackson, Phylogeny of the Pelecypoda, Mem. Boston Soc. Nat. Hist., iv, No. 8, p. 277. 1890.

[2] Science, vol. v, p. 166, Jan. 29, 1897.

[3] The useful term *resilum* was proposed by Dr. Dall, for the so-called internal cartilage of the hinge of bivalves; *resilial* pit may replace "cartilage pit."

other often becomes obsolete in the adult. The Pectinidæ all retain both these structures in a decidedly primitive form. The ligament is thin and but little differentiated, and occupies a straight, narrow marginal groove along the whole of the hinge-line. The resilium is wedge-shaped or triangular, nearly central, with its apex joining the ligament. This seems also to be nearly the condition in the youngest shells of this group that I have been able to examine. The very early stages figured by Dr. Jackson seem to indicate the same thing.

The post-veliger shells, "nepionic stage," in all the genera that I have examined, are nearly smooth, and have, at first, only slightly angulated dorsal margins, indicating the origin of the auricles, but the auricles develop rapidly and soon become sufficiently evident, the anterior one developing more rapidly and showing a byssal notch very early. In some species, like *C. vitrea*, the posterior auricle always retains its early undeveloped form.

In most species the form of the shell, characteristic of the family, is developed before the larval shell or "spat" is 1^{mm} in diameter. When about $1\frac{1}{2}$ to 2^{mm} in diameter the characteristic sculpture usually begins to appear. In most forms this consists at first of a number of small, straight radial riblets on both valves. These may or may not be accompanied by a peculiar, divergent vermiculation or "camptonectes-sculpture." When the latter appears at all, it either slightly precedes, or is simultaneous with, the radial riblets.

A few species, like *P. simile* (Pl. xvii, figs. 8, 8a), do not distinctly develop either of these forms of radial sculpture at any stage, but seem to retain through life the simple condition of the smooth or radially striated larval shell, as well as much of its form, with little alteration. Others retain the "camptonectes-sculpture" and fine riblets without much change (*C. striata*). Hence we may conclude that in such groups as *Hyalopecten*, *Palliolum*, and *Camptonectes* we have survivals of very primitive or archaic Pectinidæ. This is also indicated by the very feeble differentiation of the posterior auricle, so noticeable in *C. vitrea* (Pl. xviii, fig. 6, 7, 10, 11) and in *P. simile* (Pl. xvii, fig. 8). In these species the posterior auricle retains the form that it has in the young spat of *Chlamys irradians* (Pl. xx, fig. 3), and other more highly specialized species.

It is possible that the power of swimming, so well developed in young Pectinidæ, was acquired by the early fossil forms, even in the palæozoic ages. Possibly some of the early small forms of this group developed the power of swimming by the sudden closure of the shell before they entirely lost their ciliated velum, so that they

may have retained, more completely than at present, a free-swimming or pelagic life. There may, very likely, have been small forms that retained the velum through life and used the valvular method of swimming when a more rapid motion than the action of cilia could give was required, in order to avoid enemies.

According to Dr. Jackson's observations on the young of *C. irradians*, the spat, at first, creeps about with its foot before it is able to swim by the valvular method, but even in that stage the byssal groove is present.[1] (Pl. xx, figs. 1, 2.)

In any case, it is probable that the first form of bivalve foot to be developed, in the later veliger-stages of primitive bivalves, would have been a simple foot adapted to adhesion to floating objects or to stationary algæ, etc., and not a foot adapted to creeping over the muddy bottom as Mr. Jackson has assumed, when considering the Nucula-like forms as the most primitive of bivalves.

We may suppose that the earliest form of adhesion was temporary, and merely for the purpose of rest during the veliger condition, and it may have been effected by means of the mere surface adhesion of a little specialized, soft, fleshy or tongue-shaped foot, aided, perhaps, by a secretion of mucus from the surface. Such a mode of adhesion to objects is common among planarians, small nemerteans, annelids, and the young forms of many groups, at the present time.

From such a primitive adhesive foot the transition to a larger foot with more specialized cells situated in a groove for the secretion of stronger byssus-like threads of mucus would have been easy.

Such threads of adhesive mucus are formed by the foot glands of many land slugs and by certain marine species at the present time (e. g. *Litiopa bombyx*, a small gastropod that attaches itself to floating sargassum in this way).

From this structure of foot the transition would have been easy

[1] The form of this foot is like that of Mytilidæ, in which the foot is used for climbing about and forming a byssus.

Dr. Jackson states that his youngest spat were not attached by a byssus, but crept about by means of the long, ligulate, grooved foot, and seemed incapable of swimming. He also observed that the spat could use the marginal tentacles for creeping about and clinging to objects. Those spat that I have observed (apparently quite as young) were capable of attaching themselves by a byssus, and when slightly older were seen to swim. When kept in still water in vessels, such spat may be much more inactive than when living in open waters, in constant motion. The form of the foot of the young spat, as described by Dr. Jackson, is better adapted for climbing over and adhering to sea-weeds than to creeping on the bottom, and requires far less specialization than does a disk-like or flattened muscular foot for creeping purposes.

to a larger foot, accompanied by a muscular development for creeping about, and the formation of a definite byssal gland and groove for more secure, but temporary, attachment.

But the power of forming such a byssus does not imply a loss of swimming habits, for we find that, at the present time, many of those species that can swim most rapidly have also the power of forming a byssus very quickly when they wish to rest, by attaching themselves to seaweeds, etc. (See notes on *Cyclopecten orbicularis*, p. 72.) These two coincident habits are particularly noteworthy in the case of the smaller and more active forms of Pectinidæ, such as *Palliolum* and *Cyclopecten*, and in the young of the larger forms, such as *C. irradians*. This fact tends to confirm the conclusion that the early Pectinidæ had similar habits.[1] The development of large, strong, or thick, ribbed and fluted shells took place later in geological time and was undoubtedly accompanied by more or less loss of swimming powers, just as the young of such species at the present time lose more or less of their swimming habits as they grow older and develop thicker and strongly ribbed shells. This loss of swimming power may, or may not, be accompanied by a loss of the power of forming a byssus. In some cases, like *Hinnites* and *Hemipecten*, it is followed by a permanent attachment of the shell to a solid object. The true *Pectens* seem to lose the byssal organs when adult, and to depend upon the weight and the form of the shell for safety.

In general, those species that are best specialized for swimming have a broadly rounded, symmetrical, and compressed shell, frequently with thin, nearly smooth valves, but generally strengthened by corrugations, undulations, external radial ribs, or internal liræ or flutings.

Species that swim but little when adult often have a high and narrow form, with the auricles oblique and usually unequal, and the byssal notch is often highly developed, while the shell itself may become oblique and unsymmetrical, or heavy and thick, with strong ribs and grooves.

Most species swim well when quite small, but many lose this

[1] The existence of a small gaping of the margins below the auricles at each end, seems to be due to the swimming habit, for the jets of matter are mainly ejected from these places (see description by Dr. Jackson). But it is difficult to ascertain whether the fossil species were gaping at these places or not. In many living species the gaping is very slight, but in those that are active swimmers it is often considerable. (See *C. opercularis*, *C. Clintonius*, *Amusium*.)

power, more or less, when adult, especially in the case of the one-sided *Pectens* and those species that have very oblique shells, like certain species of *Chlamys*, for example *C. madreporarum*, which lives, when adult, in cavities between the branches of corals from which it cannot escape. This shell becomes very oblique and has very unequal auricles. *Hinnites* has gone farther in this direction, and has become attached and irregular when adult.

C. Clintonius, when it becomes very large, seems to be nearly sedentary and is often heavily covered with barnacles, ascidians, bryozoa, etc., but I have never found it with a byssus when adult. It probably retains more or less power of swimming through life, and seems to be migratory in its habits, changing its station according to the seasons. The same is true of *Chlamys irradians* and its allies. But *C. Clintonius*, like *Amusium*, has the foot rather large and divided at the top into two lobes by a deep fissure, so that the lobes can be spread apart in the form of a terminal disk. It is probably used as a pushing organ.[1] By means of this organ these species can probably push themselves slowly about when necessary to change their positions.

The teleological reasons for the development of ribs, flutings, and other forms of sculpture on the shells have been discussed elsewhere (pp. 42, 43). It is only necessary to state here that as the strongly ribbed and fluted conditions naturally and necessarily succeed the simple and fine ribbed stages, during growth, so in geological time the strongly ribbed genera succeeded the simpler and thinner forms, though many of the latter persist at the present time. But still, strongly ribbed forms of *Pecten*, *Chlamys*, *Neithea*, etc., had already become well-developed in mesozoic times, and *Lyropecten*, remarkable for the strength of the ribs, appeared early in tertiary time. But some of the modern, thin, smooth forms have probably descended from ribbed species, by the gradual reduction of the ribs.[2] It is doubtful whether any generic or subgeneric group of Pectinidæ has been evolved since the Eocene. Even in the Cretaceous, nearly all the existing generic and sectional groups were in existence, together with a few that are now extinct.

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[1] Dr. Dall has described this organ as a terminal "sucker," but it is doubtful if it can be used for adhesion.

[2] This appears to be the case with *Placopecten* and *Lissopecten*, in which the ribs have become nearly obsolete, though they are in other respects nearly allied to *Chlamys*.

In many respects, *Amusium* seems to be one of the most specialized groups. It may have descended from ribbed species of earlier ages. When adult the byssal organs are obsolete and the highly modified foot, with its large, terminal, concave disk, serves as a pushing organ, and perhaps for creeping about. The auricles and byssal notch are degenerate in form, while the internal strengthening ribs or liræ are peculiar, secondarily acquired features, due to the special development of the thin shell for active swimming through life.

Synopsis of the principal characters available for the classification of Pectinidæ.

Shell.—The form may be broadly rounded, or high and narrow; oblique, or upright; the texture may be thin and hyaline, or thick and opaque. Sometimes a somewhat prismatic or partly pearly structure appears on the inside, but the inner surface is generally porcellaneous.

The valves may be nearly equal, or one valve (either right or left) may be less convex, or even flat; they may gape widely at both ends, or close almost completely; the margin may be simple and thin and meet evenly, or the edge of the lower valve may bend up against the upper, or it may be bevelled; more frequently the margins are scalloped and interlock. In some cases (*Hinnites*) the right valve becomes cemented to foreign objects and irregular in form, when adult.

Auricles.—These may be small or large; straight or oblique; prominent and angular, or poorly developed and obtuse; equal or unequal. The ends gape or flare apart, more or less, to contain the pallial tentacles and ocelli. The posterior auricles are sometimes nearly obsolete.

Byssal notch.—This may be deep, or shallow, or even obsolete (as in *Amusium* and *Pallium*). As its margin grows it often leaves a "fasciole," indicated by lines of growth, behind it.

Pectinidial teeth.—These may be strong or feeble; few or many; sometimes they are absent, especially in adult shells of large size. (Pl. xvi, fig. 9, *p.*)

Hinge-plate.—This may be thick or thin; broad or narrow; plain, or bearing longitudinal ribs, or oblique teeth-like processes (pl. xxi, fig. 4).

Cardinal ribs.—These are longitudinal ribs or folds, either nearly parallel with the hinge-margin or somewhat oblique; or they may

become nearly transverse and tooth-like, alternating with pits (*Pallium*).

The number of cardinal ribs may be from one to three on each end of the hinge-plate; most frequently there are one or two, the upper one forming the inner boundary of the ligamental groove, the second one somewhat divergent from the first. (Pl. xvi, fig. 6, *t*.)

Cross lines or incisions.—The upper ribs, and sometimes the other cardinal ribs, are generally crossed by numerous fine transverse grooves or incisions, alternating with ridges of about the same width. These cross-lines may be straight and regular or they may be crooked or vermiculate. They are generally more distinct in the young shell than in the adult (pl. xvi, figs. 6, 9, 12 *a*, *i*; pl. xix, figs. 1, 2, 7). In certain extinct early genera they were much more conspicuous than in any existing forms (*Neithea*, *Crenipecten*).

Auricular cruræ.—These are divergent raised ribs or faint ridges running along the inner margins of the auricles (pl. xix, figs. 6–9). Sometimes they terminate distally in a rounded denticle (pl. xvi, fig. 9, *d*); sometimes the denticle alone is present. They are often obsolete in the thick-shelled species, but are sometimes conspicuous structures (*Amusium*).

Resilium.—This is generally nearly central and triangular or wedge-shaped. The surfaces next the shell are often calcified.

Resilial pit or Chondrophore.—This may be excavated entirely within the outline of the hinge-plate, or it may project considerably below it. In typical *Pecten* the pits are unlike in the two valves. (Pl. xvi, figs. 6, 9, *r*; pl. xxi, figs. 2, 2*a*, *r*.)

Ligamental groove.—This is always narrow, submarginal, and extends along the whole length of the hinge-line. The elongation of the auricles serves to give it greater extension and importance; the exterior margin of one valve is often curved inward, partly over the groove. (Pl. xvi, figs. 6, 9, *l*; pl. xxi, fig. 2, *l*.)

Muscular scars.—The scars left by the adductor and pedal muscles often show marked differences that are, perhaps, of generic value, but unfortunately they are often very indistinct, and in the smaller species nearly or quite invisible. The scars differ considerably in the two valves, for the pedal retractors are lacking in the right valve. The pallial line is very simple. (Pl. xxi, figs. 2, 2*a*.)

Internal ribs and liræ.—The inner surface of the shell may be perfectly smooth in some of the small plain species, but in *Amusium* and some other groups special raised radial ribs, often opaque white in color, are developed independently of any external sculpture (pl. xix,

figs. 8, 9). Generally the inner surface is marked by ribs or flutings corresponding to the larger external grooves, but the internal ribs are usually bicarinate or double, especially near the margin, owing to a special thickening along each of their margins, which renders them more angular than the external gooves (pl. xvi, figs. 7, 10).

External sculpture.—The surface may be smooth, or it may be covered with sculpture of many kinds. It may differ on the two valves, or not. The most common sculpture consists of numerous strong radial ribs and grooves, alternating on the two valves, so that their ends interlock at the margin. The primary ribs as well as the grooves may be covered with smaller ribs, or by scales or spines of various kinds. The primary ribs may not increase in number with age, but become continually broader (*Pecten*), or new ribs may be introduced between them, so that the larger ribs become more and more numerous without increasing in size (*Chlamys*). Concentric sculpture may be developed on one or both valves, either with or without radial ribs. The whole surface may be evenly cancellated. There may be regular concentric undulations (*Hyalopecten*). The surface may be covered with a fine, divergent, vermiculated structure often described as "camptonectes sculpture" (pl. xvii, fig. 7, and xviii, fig. 14*a*); this may coexist with radial ribs.

Gills.—There are usually two pairs of normal fillibranchiate gills (see pl. xx, fig. 6, *g*), but according to Dr. Dall, in at least one deep-water species (*Paramusium Dalli*), there is only a single pair of gills.

Foot.—The foot shows considerable variation in form. It generally has a well-developed byssal groove, and usually a more or less developed terminal slit, which is often so large that the end of the foot can be expanded into a disk-like form (pl. xx, fig. 8). The grooved side of the foot is turned obliquely downward to the right (pl. xx, fig. 6, *f*). The pedal retractor muscle is usually developed only on the *left side*, so that its scar is lacking on the right valve.

Palpi.—These are generally large and broadly triangular organs, strongly fluted on the apposed surfaces. (Pl. xxi, figs. 1, 2, *d*, *d'*.)

Labial tentacles.—These are usually much-branched organs surrounding the mouth or situated at the sides and in front of it. They may be few or many. Sometimes they are free, in other cases more or less webbed together, and often more or less attached to the bases of the palpi (pl. xx, fig. 6, and pl. xxi, figs. 1, 1*a*, 3, *e*).

Sexes.—Some species are known to be diœcious, others are known to be monœcious, but most of the genera and species have not been studied with reference to this character.

Pallial eyes and tentacles.—All the larger forms have very numerous marginal, pallial tentacles, varying in size and length and generally arranged somewhat in relation to the size of the corresponding radial ribs and grooves of the shell. There is a separate inner row or rows of "guard tentacles" on a raised inner pallial fold (pl. xx, figs. 5, 6, 7, 8a). The marginal tentacles are accompanied by a series of well-formed pallial eyes, very lustrous while living, and having a crystalline lens. These eyes in the larger species are numerous, and differ in size, the larger ones corresponding to the primary ribs, the smaller ones alternating in pretty regular order, according to the sculpture (pl. xx, figs. 6, 6*a*). The tentacles and eyes extend all the way around the margin of the mantle, beyond its free portions and even to the end of the auricles, which usually gape at the ends to give room for these organs. The tentacles and eyes are more or less reduced in the anal region. In some of the small deep-sea forms there are but few eyes, and in some cases they are not pigmented (at least in alcoholic specimens).

Remarks on the Nomenclature of Pectinidæ.

There is still so much diversity of opinion in recent malacological works concerning the nomenclature of the genera and subordinate groups of Pectinidæ that a brief review of the subject seems warranted. In general, the subdivisions here adopted correspond in most cases pretty nearly with those defined by Stoliczka,[1] with some additional ones. But as Stoliczka considered that the antebinomial names of Klein (1753), should take precedence of those given under the binomial rules, there is considerable disparity in the nomenclature. Mr. Dall[2] has more recently discussed several of these groups. He followed the more generally adopted rules respecting priority of names, and therefore his conclusions were more nearly in accord with those adopted by me.

The most fundamental and important question to be settled in the nomenclature of this family is the correct application of the name *Pecten* to one of the restricted modern genera. The old genus *Pecten* has been divided by various authors into several genera, subgenera, and sections, of very unequal value. Many of them were not definitely defined by their authors, and for several no definite

[1] Ferd. Stoliczka, Mem. Geol. Survey of India. Cretaceous Pelecypod Fauna of southern India, Vol. iii, pages 423–430, 1871.

[2] W. H. Dall, Bull. Mus. Comp. Zool., xii, pages 210–219, 1866.

type-species were given. There is, therefore, much diversity of usage regarding their names and limits. The type-species of *Pecten* itself has not yet been settled. The name is of very ancient origin. It seems to have been first used, under the binomial system, by Müller in Prod. Zool. Dan., 1776. His first species was *P. maximus* L. The same is true of DaCosta (1778), and Cuvier (1798). H. and A. Adams cited Linné as authority for *Pecten*, with *P. varius* as type, but I cannot find any basis for so doing, for Linné never adopted the genus. Fischer and others go back to ancient polynomial writers for the name, but the works of such authors should have no influence in determining priority of names under the binomial system.

The determination of the true type of *Pecten* depends upon what rules of nomenclature one adopts. If we follow the well known and important rule that priority of binomial names does not apply to the names in works earlier than the 10th edition of Linnæus, we must treat the names given by Klein as dating only from the time when first adopted by a binomial writer. Much of the confusion and disagreement in the nomenclature of authors is due to the neglect of this rule by several prominent writers. By the application of the rule much confusion may be avoided in the future. Klein, himself, merely adopted the name *Pecten*, from much earlier writers, in a somewhat restricted or modified sense. His first division of *Pecten* was made for the one-sided species, and the first species in his list was *P. maximus*. On a subsequent page, however, he gave the name *Vola* to another species of the same group. The latter, judged by his own diagnosis and figure, should have been placed in his first section of *Pecten*.

The author who first subdivided an old genus has the right, under the rules generally adopted, to assign the old name to either division unless there be very positive evidence that a special type had previously been designated by its originator.

The first binomial writer to subdivide *Pecten* and restrict the name to a particular type was Bolten, 1798.[1] He divided it into

[1] As Bolten's work is rare, I here reproduce an extract from it relating to the Pectinidæ, furnished to me by Dr. Dall. "Bolten in 1798 worked in a very rational manner. He divided the old genus *Pecten* as follows:"

CHLAMYS.

1. GLABR.E. *Striatæ* (two names of species, both = *P. islandicus*). * * *Sulcatæ* (10 species; *citrina, glabra, tranquebarica, gibba, radula*). *Plicatæ* (15 sp.; *cornea, crocea, rubiginosa* are identifiable).

three genera: Amusium (type *A. pleuronectes*); *Chlamys* (type = *C. Islandica*); *Pecten* (type *P. maximus*, also *dubius*, *Jacobæa*, etc.)

He gave no diagnoses, but cited well known and figured species as types, so that his meaning is clear.

Schumacher, in 1817, undoubtedly ignorant of Bolten's work, again divided *Pecten*. He restricted *Pecten* to the group called *Chlamys* by Bolten, and for the true *Pecten* he proposed the name *Janira*. He used *Amusium* for the same type as Bolten, and established another good division under the name *Pallium*, for *P. plica* Linné.

The genus *Amusium* was adopted by Bolten from Klein, and its type has never been in doubt.

The genus *Chlamys* of Bolten included a large majority of the species included in the genus *Pecten* by Lamarck and most of the conservative writers. The name was adopted by H. and A. Adams for a small and ill-defined section of *Pecten*, while most of the more typical forms cited by Bolten were retained in *Pecten*, so that *Pecten* of H. and A. Adams (type, *P. varius*) is practically the same as *Chlamys* of Bolten.

Fischer, 1887, adopted *Chlamys*, in its widest sense, to include the greater part of the family *Pectinidæ*, such groups as *Pseudamusium*, *Pallium*, *Lyropecten*, *Camptonectes*, and several others, being regarded as its subgenera or sections. But *C. Islandica* was cited as the special type of the restricted group.

Stoliczka, 1871, adopted *Chlamys* in a more restricted sense, with *C. bifrons* Lam. as the type. He followed H. and A. Adams in adopting *Pecten* for a very large group, with *P. varius* Linné as the type, while the true genus *Pecten* was called *Vola* (after Klein and H. and A. Adams). It is singular, however, that none of those writers who have adopted Klein's generic names have referred to the fact that Klein himself placed the one-sided pectens in the first section of his genus *Pecten*, and that his *first* "*species*" included *P. maximus!* On a subsequent page he gave *Vola*, with a brief diagnosis, for a single species of the same group, evidently not realizing its close affinity to his typical *Pecten*. Thus *Vola* was a synonym of *Pecten* even in the work of Klein!

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2. Scabriusculæ. *Nodosa* (1 sp.; *P. nodosa*). *Squamatæ* (13 sp.; *P. pallium*, *sulphurea*, *porphyrea*, *aurantia*, *pusio*, *varia*, *lingua-felis*, *incarnata*, *pseudamusium*, and *vitrea* are identifiable.)

PECTEN.

(*P. maxima*, *dubia*, *Jacobæa*, *pictus*, *ziczac.*)

AMUSIUM.

(*P. pleuronectes*, *japonicum*, *Laurentii.*)

Synopsis of the generic and sectional groups of Pectinidæ.

After the previous explanations it will, perhaps, be useful to give, in a brief summary, the divisions of the old genus *Pecten* that seem worthy of recognition, either as genera, or subgenera, or sections, with their original types, so far as they can be fixed. The groups are here arranged in the order of their sequence in date, under the binomial system. Several fossil genera are here included, for comparison with modern forms, but some fossil groups are omitted for lack of accurate knowledge of their characters.

Pecten Müller, 1776. Type, *P. maximus* Linné.

Pecten (1st section) Klein. 1753 + *Vola.*

Pecten Müller, Prod. Zool. Dan., 1776 (*pars*); *Pecten* Bolten. 1798 (rest.); DaCosta, 1778; Cuvier, 1798; Lamarck, Syst., 1801.

Janira Schumacher, 1817: Dall (*pars*) 1886; Fischer, 1887.

Vola H. and A. Adams (after Klein), 1858; Stoliczka, 1871; Zittel, 1881.

Vola + *Janira* Chenu, 1862.

Since Bolten, in 1798, definitely restricted the name *Pecten* to this group, as explained above, his restriction has precedence over that of Schumacher. The shells are generally large and heavy, and the valves are very unequal even when very young. The right valve is strongly convex with a large and much incurved umbo and beak, while the left valve is flat or even concave. It is usually smaller than the right, and shuts closely inside of its scalloped margin, and its umbo is nearly or quite obsolete. The auricles are of moderate size and not oblique, and in the right valve they are strongly convex or excurved in the middle. This valve has a sinuous, excurved byssal notch, with obsolete pectinidial teeth. The opposed auricles of the left valve are deeply incurved to fit closely against the others. The hinge-plate in both valves has usually two or three divergent ribs on each end, of which the innermost is usually the strongest and most divergent. The resilium in the right valve rests on a shelf-like chondrophore inside the hinge-margin. A distinct tooth-like tubercle exists below each auricle within the margin of both valves. The surface of both valves has strong radial ribs interlocking at the margin. Internally there are angular, thickened and fluted radial ribs, opposite the external grooves; these ribs become more prominent and bicarinate or fluted near the margins.

Some of the species are known to be hermaphrodite. The foot of *P. maximus* is described as spatulate at the end.

Chenu and some other writers have made two generic divisions of the one-sided *Pectens*, viz: *Vola*, type *P. maximus* L.; and *Janira*, type *P. atavus*. The latter is a fossil of cretaceous age. No important diagnostic characters have been pointed out, however. These two names, as originally used, were absolutely synonymous.

This genus occurs in rocks as early as the lower Cretaceous. The extinct group *Neithea* is closely allied. It differs only in having conspicuous transverse incisions on the upper cardinal ribs. *Pecten* has a wide distribution in all tropical and subtropical seas. *P. ziczac* L. and *P. hemicyclicus* Ravenel occur in the West Indies; *P. dentatus* is found on the Pacific coast of America, from the Gulf of California to South America.

Amusium Bolten. Type, *A. pleuronectes* (Linné).

Amusium Bolten, 1798; Muhlfeldt, 1811; Schumacher, 1817; Woodward, 1866; Dall, 1886.

Amussium (*pars*) H. and A. Adams, 1858; Stoliczka, op. cit., p. 426, 1871; Fischer, 1887; Zittel, 1881.

Pleuronectia Swain., 1840; Chenu, 1862.

In this very distinct generic group the shell is round, thin, nearly smooth and strongly compressed. The surface is often polished, sometimes lightly radially striated, never strongly ribbed. The margins are simple and thin. The valves may be a little unequal in convexity and usually differ in color, and somewhat in sculpture. The valves come together ventrally, but usually gape at both ends. The auricles are small, symmetrical, nearly equilateral, often with lateral cruræ; the byssal notch is small or absent, pectinidial teeth nearly or quite abortive. The adult probably has no byssus. Hinge-plate simple. Interior of valves strengthened by a number of raised divergent ribs, or liræ, independent of any external sculpture. According to Dr. Dall, the foot in *A. pleuronectes* = *Mortoni* is large, with "a spade-shaped tip and well-developed sucker, with moderate stem." In *A. Dalli* it is described by him as having the "sucker large, hood-shaped, thin-walled and darkly pigmented, with a broad base, abruptly enlarged from a very slender stem." The stem is strongly grooved, the expanded cord is hollow and forms "an exaggerated and efficient sucker." The ocelli are without pigment.

In the latter species there is but a single gill on each side, "furnished with long separate filaments, much as in *Dimya*."[1]

[1] Owing to these important differences in the structure of the gills and foot, it seems necessary to place this species in a distinct genus, for which I have proposed the name *Paramusium*. (See p. 72.)

The expanded end of the foot, in this and some other genera, is probably used as a *pushing* organ rather than a "sucker," as supposed by Dr. Dall. It is analogous to the large pushing disk on the foot of *Nucula* and *Leda*. A sucker would not be of much use on the soft mud where many of these species live.

The type of this genus is from the East Indies; other large species, closely allied, are found at Japan (*A. Japonicum*), and elsewhere.

A species, referred, at first, by Dr. Dall to *A. pleuronectes* (L.), but perhaps the *A. Mortoni*, and *A. Dalli* were dredged in the West Indies and Gulf of Mexico by the "Blake" Exp. The latter ranged from 218 to 1591 fathoms. The former was from 35 to 60 fathoms. Most of the species are from deep water and mud or ooze bottoms.

Species of the genus occur fossil in Cretaceous and Tertiary rocks.

Curiously enough, H. and A. Adams did not give the presence of internal ribs as a character of the genus, but based it only on the form of the shell. Accordingly, they included our large American species, *C. Clintonius* or *Magellanicus* in the genus *Amusium*, from its general external resemblance to shells of that group. It is really much more nearly allied to the typical species of *Chlamys* and *Pseudamusium*, so far as the shell is concerned.

Amusium must be restricted to those species having specialized, internal, radial ribs and small auricles.

Chlamys Bolten. Type, *C. Islandica* (Linné).

Chlamys Bolten, Mus. Bolt., ed. I, p. 165, 1798, restr.; Fischer (*pars*), 1887.

Pecten (restr.), Schumacher, 1817.

Pecten (*pars*) and *Chlamys* (*pars*), H. and A. Adams, 1858; Chenu, 1862; Zittel, 1881.

Pecten (restr.), Stoliczka, 1871.

PLATE XVI. figs. 2–5. PLATE XX. fig. 9. PLATE XXI. fig. 2.

As stated on a previous page, the original type of this genus is identical with *P. Islandicus* (Linné). Therefore this should be adopted, without question, as the true type, as has been done by Fischer and others.

The group called *Chlamys* by Stoliczka is the same as *Æquipecten* Fischer, 1866; it is usually regarded as a mere section of *Chlamys*. (See p. 67.)

The typical species of *Chlamys* are high, rounded, somewhat oblique, nearly equivalve shells, with large inequilateral and oblique auricles; a large byssal notch; and several pectinidial teeth. The surface is strongly radially sculptured, both with primary and with

numerous interpolated ribs, increasing in number with age. The ribs are generally crossed by concentric sculpture, often forming rough scale-like projections. The margins are scalloped and the shell closes rather tightly except at the byssal area. The inner surface has ribs and double flutings, corresponding to the external grooves and radii. The hinge-plate generally has two slightly divergent ribs on each end. For some account of the anatomy of *C. Islandica*, see p. 72. Some of the species are known to have separate sexes.

The genus is world-wide in distribution. It appeared early in mesozoic geological time (Triassic) and is common in Cretaceous and Tertiary rocks.

Among the American species of *Chlamys* are the following, belonging to the typical or restricted group: *C. Islandica* Linné, from the northern coasts and fishing banks; *C. ornata* (L.), from the southern coasts of the United States and the West Indies; *C. exasperata* (Sow.), West Indies; *C. costellata* Verrill and Bush, from deep water; *C. Benedicti* V. and B., from deep water off the eastern coast of the United States and in the West Indies; *C. phrygia* (Dall), Gulf of Mexico and West Indies, 95–127 fath; *C. effluens* (Dall), 127 fath., off Havana. Several of the common American species belong to the subgenus *Æquipecten* (see p. 67). Among them are *C. irradians*, *C. dislocata*, *C. Antillarum*, *C. glypta* (pl. xvi, figs. 7–11), and *C. ventricosa*.

Pallium Schumacher. Type, *P. plica* (Linné).

Pallium Schumacher, 1817; H. and A. Adams, 1858; Chenu, 1862; Stoliczka, 1871; Zittel, 1881; Fischer, 1887.

Dentipecten Ruppel, 1835.

Plate XXI. fig. 4.

The special feature of this very distinct group is the development of several (usually three) well-marked, nearly transverse, blunt teeth, alternating with distinct pits, on each end of the hinge-plate. The shell is elevated, rather thick, with external, large, obtuse or rounded, radial ribs or corrugations and with internal, angular, double or bicarinate ribs, opposite the external grooves, near the margin. The auricles are small, but high. The hinge-teeth are marked with distinct cross lines.

Hinnites Defrance, 1821. Type, *H. Cortessi* Def.

Shell free and much like *Chlamys*, when young, but later in life it becomes attached by the right valve and irregular. Mr. Dall has

described *H. Adamsi*, from the West Indies, in deep water. *H. pusio* is from the European coasts. Other species occur in the East Indies. The type is an extinct tertiary species.

Neithea Drouet, 1824. Type, *P. æquicostatus* Lam.

This group agrees in form and sculpture with typical *Pecten*. It differs chiefly in having a series of transverse denticles and pits along the dorsal border of the hinge-plate. These seem to be homologous with the much finer transverse incisions and denticles found in many living Pectinidæ, but are more highly developed. It seems to be scarcely more than a subgenus or section of *Pecten*.

All the species are mesozoic fossils.

Hemipecten Adams and Reeve, 1849. Type, *H. Forbesianus* Ad. and R.

This group includes species with thin, irregular shells attached by the right valve, like *Hinnites*, but the attachment is effected mainly by a permanent modified byssus. The posterior auricles are nearly obsolete. The byssal notch becomes irregular and nearly enclosed, as in *Anomia*. I do not know any American species.

Aviculopecten McCoy, 1855. Type, *A. concavus* McCoy.

Shell broad, roundish, more or less inequilateral and oblique, with regular radial sculpture. Auricles unequal, the anterior smaller with a byssal notch. Hinge-plate without a central resilium, but with a ligamental groove along its entire length. The absence of a central resilial pit renders it doubtful whether this genus should be placed in this family. It may belong rather to *Aviculidæ*.

The genus is confined to the Palæozoic rocks.

Pseudamusium H. and A. Adams. Type, *P. exoticum* (Chem., Lam.)

Pseudamussium (*pars*) H. and A. Adams, 1858 (after Klein); Chenu, 1862; Stoliczka, 1871; Zittel, 1881; Fischer, 1887; Dall (*pars*) 1886.

PLATE XVII. figs. 8, 8*a*.

The typical species of this group have nearly smooth, round, symmetrical, closed shells with well-defined, small, straight, obtuse-angled auricles. The valves are nearly equal, and have nearly simple, even margins. The external sculpture consists of small radial striæ or riblets, without strong angular ribs and grooves, and it may differ on the two valves; the margin is not scalloped, or but faintly so, and there are no definite internal ribs. The hinge-plate usually has but one longitudinal fold on each end; this is feeble and nearly

parallel with the marginal ligamental groove. It is usually cross-incised. The byssal notch is small and the pectinidial teeth are up to five in number, or sometimes lacking. Some of the species, if not all, show the fine divergent "camptonectes-sculpture," on one or both valves, especially when young.

This group was adopted by H. and A. Adams, from Klein, but they gave no adequate definition, and designated no special type. They gave an alphabetical list of twenty-one species. Among these are representatives of several diverse groups (*Amusium*, *Cyclopecten*, *Chlamys*, *Palliolum* or *Camptonectes*, etc.). If these incongruous groups be eliminated, those that remain may be referred to the group characterized above, with such species as *P. dispar* (Lam.) and *P. exoticum* (Lam.)=*pseudamusium* (Sowerby) as typical forms, whether they be distinct species or not.

Klein, himself, referred to his genus certain fossil shells which, as he stated, differ from *Amusium* only in lacking ribs and grooves. He also cited one of Lister's species, with his diagnosis, but he gave it no name. His figure (copied from Lister) is a crude representation of a variegated species, like *P. exoticum* or *P. dispar*.

Although I do not, personally, consider Klein's type as of any importance in the limitation of the group, it may satisfy others to know that his type is the same as that adopted above.

Chenu, 1861, gave as "examples" three species: *P. dispar* (Lam.); *P. pseudamusium* (Lam.); *P. glaber* (Linné). The first two are typical, but the last belongs to another section.

Stoliczka gave a definition of the group, with *P. exoticum* as the type. He also cites *P. corneum*, *P. hyalinum*, *P. tigrinum*, and *P. natans* as typical examples. Some of these belong in diverse groups.

Zittel, in 1881, gave *P. glabrum* and *P. hyalinum* as types.

From the incongruous species included in this group by H. and A. Adams and others, we may well separate those that have internal ribs, and also the thin, delicate, deep-sea species, with unlike valves, the right valve usually having strong concentric sculpture. For this last group I have established the genus *Cyclopecten*. Of the American species, our common large New England species, *P. Clintonius* or *Magellanicus* (Lam.) resembles this subgenus. It is similar to the typical species in form of shell and auricles. It differs mainly in gaping at both ends and having stronger radial sculpture on the upper valve. But the character of the shell and the form of the foot are so peculiar as to warrant the institution of a special genus or subgenus for its reception (see p. 69).

Of the European species examined by me, *P. similis* (pl. xvii, figs. 8, 8*a*) seems to belong to the restricted group. Allied species occur in the Tertiary and Cretaceous formations.

Camptonectes Meek, 1864. Type, *P. lens* Sowerby.

Camptonectes Stoliczka, 1871; Zittel, 1881 (type, *arenatus* Goldf.).

Shell subovate, plain, not corrugated, and without strong radial ribs; margin nearly plain. Valves subequal. Auricles unequal; byssal notch well developed. Surface of the shell covered with fine, obliquely divergent, curved, crenulated or vermiculated riblets with intervening, narrow, punctate grooves.

The curious vermiculated sculpture is not peculiar to this division, but is more or less obvious on the shells of some species of *Pseudamusium*, and on species of several other groups, both with and without radial ribs. It is a structural feature that runs obliquely across the ribs and grooves. Most of the species are mesozoic fossils.

The recent *Pecten striatus* and *P. tigrinus* Lam. of Europe, apparently belong to this group, and *P. Testæ* might, also, well be referred to it. It is generally regarded as only a section of *Pseudamusium*.

Entolium Meek, 1864. Type, *D. cornutum* Queenst.

Body of shell rounded, not oblique; valves thin, nearly equal. Sculpture delicate. Auricles well developed, those of the right valve prolonged dorsally beyond the hinge-line in the form of angular lobes. Byssal notch obsolete. Apparently there are no internal ribs or liræ. This genus appears to be allied to *Amusium*, which it resembles in the form of the disk, shortness of the auricles, absence of byssal notch, and apparently in the texture of the shell. But it differs in lacking the internal liræ, and especially in the dorsal prolongation of the auricles. The last character distinguishes it, also, from *Protamusium* V., to which it appears to be still more closely related.

Syncyclonema Meek, 1864.

Type=*P. rigida* Meek and Hall, Mem. Amer. Acad. Arts and Sciences, Boston, vol. v, p. 381, pl. i, figs. 4, *a*, *b*, *c*=*P. Halli* Gabb.

Syncyclonema Meek, Smithsonian Check List Cret. Fossils, p. 31, 1864.

The type of this group is a small, poorly preserved, thin shell, with concentric grooves or undulations on at least the "left or inferior" valve, and with radial striæ on the other. The shell is compressed, obovate, higher than long, not oblique, gradually narrowed to the

auricles, which are small and nearly equal, and apparently differ but little in sculpture, but the actual sculpture of the type is uncertain.

Many mesozoic fossil species appear to belong to this group. The type is from the North American cretaceous formation.

Some of the broad fossil species that have been referred to this group appear to belong rather to *Protamusium*. These have fine concentric grooves and lamellæ, and equal auricles, but no radial sculpture.

Several living delicate deep-sea species are perhaps nearly allied to this group.

As the real structure of the type of the genus is still uncertain, I have thought best to make a new genus for the recent forms, under the name of *Hyalopecten* (see p. 71).

Among the known species are *H. undatus* V. (pl. xviii, fig. 5), *H. dilectus* V. and B., *H. fragilis* (Jeff.), *H. pudicus* (Smith).

The group of shells here indicated forms a very definite division, worthy, perhaps, of generic rank. These recent species do not show the camptonectes-sculpture, but both valves are distinctly undulated. Some of these species are otherwise smooth, but others are finely radially striated. They are all hyaline, very thin, and very simple in structure.

Pernopecten Winchell, 1865. Type, *P. limiformis* W.

Pernopecten Winch., Proc. Acad. Nat. Sci., Philad., for 1865, p. 125; Hall, Pal. New York, v, pt. I, sec. II, Introd., p. lvii, figs. 1, 2

The type of this genus has the form of a small round *Amusium*, or *Propeamusium*, to which it appears to be closely allied. The auricles are small, short, subequal, poorly differentiated, much as in *Amusium*. Byssal notch slight. There is a well-developed median resilial-pit. The cardinal ribs bear a series of minute transverse grooves, or "crenulations" on each end, like those of *Euchondria*, etc. There is a well-developed, rib-like auricular crura on each end. The shell is smooth, or has fine radial striæ.

Burlington Sandstone of Iowa.

This genus should probably be regarded as the ancestral form of *Amusium* and *Propeamusium*. It was probably a free-swimming species, like the modern genera.

Lyropecten Conrad, 1867. Type, *P. nodosus* (Linné).

Lyropecten of several later authors.

Shell large and strong, corrugated, with large, fluted, and usually nodose, primary radial ribs, which do not increase in number, and

with coarsely scalloped margins. Valves somewhat unequal. Auricles of medium size, unequal. Hinge-plate with several, usually three, oblique, divergent ribs on each end. This is one of the best defined groups, and may be regarded as of generic value. It is allied to *Pallium*.

Several species occur in the American tertiary deposits. *L. nodosus* occurs at Florida and in the West Indies. *L. subnodosus* is from the tropical regions of the Pacific coast of America. *L. corallinoides* (D'Orb.) is from West Africa and the Canary Islands; *L. noduliferus* (Sow.) is from East Africa.

Euchondria Meek, 1874. Type, *E. neglecta* (Geinitz).

Euchondria Meek, Amer. Journ. Sci., 3d ser., vol. vii, p. 443, 1874; Hall, Pal. of New York, v, Pt. 1, sec. II, Introduction, p. lxii, figs. 4, 5, 1885.

The shell of the type of this genus has nearly the form of *Cyclopecten* and *Propeamusium*, to which it seems closely allied. The auricles are well-developed and angular, subequal. The body of the shell is well rounded; the sculpture is slight, consisting of concentric lines on the body, but there are radial ridges on the auricles. There is a distinct triangular chondrophore, situated slightly one side of the beak. The hinge-plate has a row of very small, close, incised, transverse pits or grooves on each end. These seem to correspond closely with the grooves, alternating with denticles, on many modern species, and not with ligament pits.

Carboniferous of Illinois.

Propeamusium Gregorio, 1883. Type, *P. inequisculpta* Tib. = *P. fenestratum* Forbes.

Propeamusium (subgenus) Dall, Bull. Mus. Comp. Zool., xii, p. 210, 1886; Fischer, 1887.

PLATE XX. figs. 5–9.

This group is a subdivision of *Amusium*. It includes small, mostly deep-sea species, with rounded thin shells, having the valves unequal in size and sculpture; the lower and flatter one is concentrically grooved, and usually turns up at the thin margin to meet the upper valve, as in *Cyclopecten*. The upper valve may be cancellated or radially sculptured. When full grown there are several well-formed, raised, internal ribs; these may be absent in the young.

This division differs from *Amusium* in the sculpture of the valves and in having the auricles and byssal notch well-developed.

The species closely resemble those of *Cyclopecten;* the only obvious difference in the shell consists in the internal ribs. The species

are mostly from the deep sea, and several are from the West Indian area. *P. thalassinum* (Dall) is the only species taken off our northern coast, and this is not a typical species, as it has but two radial ribs, besides the auricular cruræ. Dr. Dall has recorded the following species from the West Indian region: *P. Pourtalesianum* Dall, 13 to 805 fath.; *P. cancellatum* (Smith), 13 to 1591 fath.; *P. Holmesii* Dall, 100 fath.; *P. Sayanum* Dall, 16 to 150 fath. He also records *P. Alaskensis* Dall, from Alaska; *P. Hoskynsi* (Forbes, *non* Sars, *nec* Jeff.) from the East Atlantic and Mediterranean; *P. lucidum* (*pars*) Jeff., East Atlantic and off Brazil, 675 to 1000 fath.

The following additional species, described as species of *Amusium*, were obtained by the Challenger: *P. scitulum* (Smith), 28 fath., off New Guinea; *P. Torresi* (S.), 155 fath., off Cape York; *P. propinquum* (S.), 100 fath., off the Azores; *P. obliquum* (S.), 390 fath., West Indies. *P. thalassinum* was taken in 43 and 417 fath.

Crenipecten Hall, 1883. Type, *C. crenulatus* Hall; Devonian.

Crenipecten Hall, Pal. of New York, vol. v, pt. I, plates and expl., p. 3, 1883; sect. I, Introd., p. xii, pl. ix.

The shell and auricles are shaped much as in *Euchondria*. Some of the species show radial sculpture.

The hinge is said to have no median resilial pit, but to have a continuous series of small transverse pits, grooves, or incisions, along the whole of its length. These minute pits are probably of the same nature as those of *Euchondria* and many modern Pectinidæ, and not ligament-pits.

Several species have been described from the Chemung and Waverly formations.

The alleged absence of a resilial pit is the only tangible difference between this and *Euchondria*.

Palliolum Monterosato, 1884. Types cited: *P. Testæ* Biv. and *P. vitreum* (Chem.)

PLATE XVIII. figs. 6–14.

This is a group separated from *Pseudamusium* of H. & A. Adams, and is scarcely to be distinguished from *Camptonectes*.

The two species named by its author as types agree in having thin, rounded, nearly equivalve, shells, with the posterior auricle poorly developed, and with fine camptonectes sculpture on both valves, with small radial riblets, and usually with rows of small scales. The margins are plain and come evenly together, without flattening.

They are closely allied to *P. striatum* (pl. xviii, figs. 14, 14*a*) in form and sculpture and, like the latter, might well be referred to *Camptonectes.*

The second type-species (*P. vitreum*) is rather more distinct, on account of the very slight differentiation of the posterior auricle, which is small and resembles the condition seen in the very young examples of other species. This feature is also present in the other species in a somewhat less degree.

P. vitreum (pl. xviii, figs. 6–13) has a broad, round, thin hyaline shell, with the auricles unequal; the posterior auricle is short and only slightly differentiated from the shell; it has an obtuse dorsal angle from which the margin slopes to the body of the shell, without a notch or angle. It has a number of sharp, free, pectinidial teeth and a long series of discarded ones above the byssal fasciole. Auricular cruræ are rather prominent. The byssal notch is deep, and the byssus is well developed. It is used to attach the shell to branches of gorgonian corals (*Acanella*, *Primnoa*), etc. The "camptonectes-sculpture" is strongly marked. The mantle has rather few tentacles and pigmented ocelli.

This arctic and northern European species has been recorded (Voy. Challenger) from the E. Indies, 100–700 fath., and from off Japan, 345 fath., and off Patagonia (140 to 400 fath.) It is common on the deep-water fishing grounds off Nova Scotia and Newfoundland, in 57 to 400 fathoms, and extends southward in deep water down to 1537 fath., off Chesapeake Bay.

P. Testæ is less hyaline, and the auricles are more nearly equal. It has well-marked camptonectes-sculpture and radial riblets on both valves. There are several pectinidial teeth. According to Jeffreys (Brit. Conch., v, p. 167), the animal of this species has two unequal rows of slender tentacles, the inner row much the smaller. Ocelli few, in two rows, those in the outer row unequal in size and position; those of the inner row are much smaller and more numerous. Foot cylindrical. It swims actively and often attaches itself by a byssus.

It has been brought up attached to a telegraph cable from the depth of 1000 fathoms in the Mediterranean.

My conclusion is that these two species must be placed in the same section with *P. striatum* and *P. tigrinum.* Nor can I see any valid reason why the four should not be placed in *Camptonectes.*

It is true that the "camptonectes sculpture" is found also in larger species of allied groups when young (e. g. *P. Clintonius*), and also in certain ribbed species of *Chlamys*, but in the typical forms referred to *Camptonectes* it is the predominant sculpture through life.

These may be regarded as primitive and simple forms, from which larger species with stronger ribs have been developed without losing this primitive fine sculpture. But this kind of sculpture depends upon structural features that must be taken into account in the classification of the family. Possibly all true species of *Pseudamusium* have, also, the camptonectes sculpture, but I have not at hand snfficient material to settle this question.

It appears to be lacking in *Cyclopecten*, *Pectinella* (typical), *Propeamusium*, *Amusium*, *Paramusium*, *Pecten*, *Lyropecten*, and *Pallium*. Nor have I observed it in various species of *Æquipecten* examined. It is also absent from many species of *Chlamys* (restr.)

Æquipecten Fischer, Manual, 1887. Type, *Chlamys opercularis* (L.)

Plate XVI. figs. 6–11. Plate XX. figs. 1–3, 6, 6a.

Shell broadly rounded, with the valves nearly equal and symmetrical. Auricles well formed, angular; byssal notch well-developed. The sculpture consists of a moderate number of large and nearly equal primary radial ribs, which increase in size, but are not much increased in number with age, by the interpolation of new ones. Internal ribs or flutings correspond to external grooves, but each one is bicarinate or double, especially near the margins. Hinge-plate with one or two slightly divergent ribs at each end, often crossed by strong transverse incisions. Pectinidial teeth abortive in the type, but present in most species. Foot of the type-species is subcylindrical, well-developed, with a byssal fissure and a terminal deeply bilobed "scoop-shaped" disk, which can be expanded. In our *C. irradians* (see pl. xx, fig. 6) the foot has a similar structure, but the terminal disk appears to be smaller. In the type there are (t. Jeffreys) 35 to 40 ocelli, and two or three irregular rows of tentacles.

The type-species of this group (*C. opercularis*) has a well-rounded, scarcely oblique shell, with the valves a little unequal and conspicuously gaping at both ends, but especially so anteriorly. The auricles are well-developed, angular at both ends, and nearly equal. The byssal notch is large, but the pectinidial teeth are nearly or quite obsolete in the adult. Both valves have about twenty-one large primary ribs, which are at first narrow and angular, but become broad and rounded by growth. In the left valve both ribs and grooves are covered with small radial riblets, decussated by fine concentric lamellæ. In the right valve the radial riblets are less distinct, but evident. The interior has about twenty-one bicarinate ribs or flutings on each valve. The hinge-plate has one broad, low,

transverse rib, besides a very narrow one bounding the ligamental groove. In the right valve the margin, above the ligament, is incurved. The auricular cruræ are feebly developed, but end in distinct denticles, larger in the right valve.

In most of the species referred to this group the valves gape much less at the ends than in the type-species.

A large number of shallow-water species from all parts of the world belong to this group. Many of them grow to large size. The following are some of the American species:—

C. irradians (Lam.) (pl. xvi, fig. 6 ; pl. xx, figs. 6, 6*a*), from Cape Cod to the Gulf of Mexico; *C. dislocata* (Say), Cape Hatteras to the West Indies; *C. Antillarum* (Recl.), West Indies ; *C. nucleus* (Born.), West Indies; *C. glypta* Ver. (pl. xvi, figs. 7–11), off the Eastern coast of U. S. and in the West Indies, 69 to 200 fath.; *C. ventricosa* (Lam.), Pacific coast of tropical America ; *C. purpurata* (Lam.), Pacific coast of South America; *C. caurina* (Gould), coast of California, etc.

Pectinella, gen. nov. Type, *P. Sigsbei* Dall.

Shell small, thin, swollen, nearly smooth, with convex and slightly unequal valves. Auricles very unequal, oblique, the anterior larger, with a deep byssal notch in the right valve, but without pectinidial teeth ; posterior auricle small. The surface is smooth except for fine lines of growth. Camptonectes sculpture is not present. The texture is not hyaline.

The only known species is *Pectinella Sigsbei* (Dall), Bull. Mus. Comp. Zool., xii, p. 223, pl. iv, fig. 2, 1886. It was taken by the Blake Exped. in the West Indies, in 158 fathoms.

This form differs so much from all the other divisions of Pectinidæ that it seems necessary to form a new genus for it. In its swollen form, it approaches some of the species of *Limopsis* and allied forms.

Lissopecten, new subgenus of Chlamys. Type, *L. hyalinus* (Poli).

Shell slightly inequivalve, broadly rounded, not oblique, thin, translucent, nearly smooth. The external sculpture consists of faint, nearly obsolete radial ridges and obscure riblets, but one or both auricles may have a more or less cancellated sculpture. The interior sculpture consists of very distinct, simple raised ribs. Auricles angular, well developed. Byssal notch deep. Pectinidial teeth prominent. Margin not scalloped, nearly plain and simple.

Although this group agrees with *Amusium* in having internal ribs without corresponding external grooves, it seems to be allied rather to *Chlamys*. It may be regarded as a division of the latter in which the external radial ribs have degenerated.

It includes *C. hyalinus* (Poli), from the Mediterranean, and several other similar small species.

Leptopecten, new subgenus of Chlamys. Type, *C. Monotimeris* (Conrad).

Shell thin, translucent, oblique, broadly rounded, with strong, rounded radial ridges or folds, like corrugations, which appear in reverse on the interior surface. The internal ribs are not angulated by a deposit of shell, nor distinctly thickened. Margin with broad scallops. The exterior surface is covered with fine divergent camptonectes sculpture, both on the ribs and intervals. The ribs do not increase in number with age, but become broader and more flattened. Auricles large and broad, thin, corrugated. Byssal notch large and deep. Pectinidial teeth prominent. Hinge-plate thin and but little differentiated. Cardinal ridge thin and small, close to the ligament, crossed by fine incisions. The resilial pit is small, but projects beyond the thin hinge-plate in the left valve.

This is a peculiar group, remarkable for its thin but strongly corrugated oblique shells, with fine camptonectes sculpture.

C. Monotimeris (Con.), from the California coast, is the only species studied.

Placopecten, new subgenus of Chlamys. Type, *P. Clintonius* (Say).

PLATE XVII. figs. 1–7. PLATE XX. figs. 7, 8, 8a. PLATE XXI. figs. 1, 1a, 2, 2a.

Shell large, compressed, broadly rounded, rather thin, with simple sharp edges, meeting evenly ventrally, but gaping considerably at both ends, especially when adult (pl. xvii, fig. 5). Valves only slightly unequal in form, the right one being a little flatter, but they differ in color and somewhat in sculpture, the right one being smoother and paler. Both have fine radial lines or riblets, and they have vermiculated divergent riblets when young. Auricles small, symmetrical, nearly equal. Byssal notch small, simple. Pectinidial teeth generally obsolete, except when young. No internal ribs. Inner surface often with more or less pearly luster and a crystalline structure. Hinge-plate with two feeble, slightly divergent ribs on each end, crossed by fine transverse incisions. The foot (pl. xx, fig. 8) is well developed, oblique, slightly narrowed distally and enlarged at the end, where it is divided into two lobes by a rather deep,

oblique, longitudinal fissure, so that the lobes can be spread apart or closed, at will, thus resembling somewhat the foot of *Ledidæ*. Toward the base, on the anterior side, there is also a short, deep byssal slit, terminating at a prominent tubercle about the middle of the front side.

Cyclopecten, gen. nov. Types, *Pecten pustulosus* Verrill; *P. imbrifer* Loven.

Plate XVI. fig. 1. Plate XIX. figs. 1–4.

Shells thin, rounded, scarcely oblique, with symmetrical auricles and simple margins. The two valves are unlike in sculpture. The right valve is a little flattened and upturned at the flexible margin, so as to fit tightly against the upper valve. The thin lower valve has, in the typical species, regular, thin, elevated, concentric lamellæ,

Fig. 1.

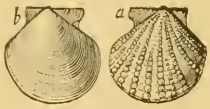

Figure 1.— *Cyclopecten pustulosus* V.; *a*, left, *b*. right valve, natural size.

which aid in the adaptation of the edge to that of the upper valve; the margin is usually flattened or bevelled. The upper (left) valve is radially sculptured, rarely smooth; it usually has radial rows of arched scales, pustules, or points, and also concentric raised lines; it is sometimes cancellated. No radial ribs, nor interlocking points at the margin. Auricles well developed, subequal, angulated and well-defined at both ends; byssal notch well defined; few or no pectinidial teeth. Cardinal folds single, rather feebly developed, often cross-lined. Eyes few. Byssus small, and of few threads.

The species of this group have usually been referred to *Pseudamusium*, but they differ widely from the typical forms of that group, such as *P. exoticum*, *P. dispar*, etc., in which the valves are of nearly equal size, with simple edges that come evenly together without flexure of the lower one, and in which the auricles are small and nearly equal.

This genus includes a large number of small species, mostly from deep water. Among these are the following: *C. imbrifer* (Lov.), northern coasts of Europe; *C. pustulosus* (Ver.) (cut, fig. 1), (pl. xix, figs. 3, 4); *C. subimbrifer* (V. and B., see p. 84), 121 fath.; *C. leptaleus* (Ver.), 142 fath.; *C. nanus* V. and B.; (pl. xvi, figs. 12–12c), the last four are from deep water off the eastern coast of the

United States; *C. reticulus* (Dall); *C. simplex* Ver. (pl. xvi, fig. 1, xix, figs. 1, 2); and *C. Culebrensis* (Smith), 390 fath., are from the West Indies; *C. Murrayi* (Smith), 1400 fath., off Australia; *C. clathratus* (Mart.), 120 fath.; *C. subhyalinus* (Smith), 400 fath.; and *C. distinctus* (Smith), 100 fath., from the Antarctic regions; *C. Kermadeciensis* (Smith), 600 fath., off Kermadec I.

C. orbicularis (Sowerby), which occurs on the west coast of Africa, living among, and usually attached to, floating fucoids (*Sargassum*, etc.), near the shore, appears to belong to this genus. It has concentric sculpture on both valves; that on the left forms raised scale-like lamellæ. The shell is hyaline. The valves close tightly by the upturning of the edge of the right one. According to Dr. Charbonnier (Journ. de Conch., ser. II, vol. iv, p. 261) this species swims about very actively, but attaches itself very firmly and quickly (in 15 minutes), to floating algæ by a byssus of several threads. When at the bottom of the glass vessel, it creeps about by means of its foot.

Hyalopecten, gen. nov. Type, *H. undatus* V.

PLATE XVIII. fig. 5.

Shell compressed, thin, hyaline. Valves nearly equal, with concentric undulations or corrugations, affecting the entire thickness; margins simple; sculpture none, or consisting of fine radial lines on one or both valves, without camptonectes sculpture. Hinge-plate thin and nearly plain; auricles well developed, unequal; byssal notch distinct.

The possible relations of this group to *Syncyclonema* were discussed on page 63.

The species known to me are as follows: *H. dilectus* V. and B., from 1813 fath., off Martha's Vineyard; *H. fragilis* (Jeff.), from northern Europe and the Arctic Ocean, and off the U. S. coast, in 578 to 1525 fath.; *H. undatus* Ver., off the U. S. coast, in 1423 fath.; and *H. pudicus* Smith, off Marion I., in 1375 fath.

Protamusium, gen. nov. Type *P. demissum* (Phil.).

Body of shell disk-like, nearly circular, and compressed, valves thin, with fine regular concentric grooves and fine raised lamellæ. Auricles short, but distinct, angular, not oblique, nearly equal, not prolonged dorsally; no byssal notch.

This division is proposed for certain mesozoic shells that closely resemble *Amusium* in form, but appear to be entirely destitute of the internal radial ribs, so characteristic of the latter. It differs

from *Entolium* in not having the auricles strongly produced dorsally, though their distal angles are often a little prominent. The type (*P. demissum*) is from the Jurassic formation of Germany, as is also *P. disciforme* (brown Jura).

Various other allied species have been described from the Jurassic.

A considerable number of species that have been described as *Amusium*, from the Jurassic and Cretaceous, apparently belong to this group, for they show no trace of internal liræ. Among these are the following Cretaceous species: *P. membranaceum* (Nils.), from Europe and India; *P. illustre* Stol., from India; *P. sulcatellum* (Stol.), from India; *P. obovatum* (Stol. as *Syncyclonema*), from India.

Paramusium, gen nov. Type, *Amusium Dalli* Smith.

Shell thin, rounded, much compressed; valves nearly equal; sculpture nearly obsolete, different on the two valves; the lower valve has concentric undulations. Auricles very small, equal. Byssal notch and pectinidial teeth obsolete. The shell has a prismatic structure. Internal liræ and auricular cruræ well developed.

A single pair of gills, with long, simple, separate filaments (t. Dall). The foot is slender, with a byssal groove; the end is much enlarged, with an oblique, expanded, concave terminal disk, striated within. No labial palpi. Ocelli without pigment. The structure of the animal, as described by Dr. Dall, is very different from that of typical *Amusium*. *P. Dalli* ranges from 218 to 1591 fathoms, from the Gulf of Mexico to Barbados. Another similar species, *P. meridionale* (Smith), was taken by the Challenger Exp., off Brazil.

Descriptions of new species and descriptive notes on others.

Chlamys Islandica (Chemn.)

Ostræa Islandica Müller, Zool. Dan. Prod., No. 2990, 1776. Fabricius, Fauna Grönl., p. 415, 1780.

Pecten Islandicus Chemn., Conch., vii, p. 304, pl. 65, figs. 615, 616, 1784. Lamarck, Anim. sans vert., ed. 2, vol. vii, p. 145. Hanley, Rec. Biv., p. 284. Gould, Invert. Mass., ed. 1, p. 133, fig. 87; ed 2, p. 198, fig. 495. Verrill, Invert. Vineyard Sd., etc., p. 402. G. O. Sars, Mollusca Reg. Arcticæ Norvegiæ, p. 16, pl. ii, fig. 2, 1878.

Pecten Pealei Conrad, Amer. Mar. Conch., p. 12, pl. ii, fig. 2, 1831.

Chlamys Islandica Fischer, Man. Conch.

PLATE XVI. figs. 2–5b. PLATE XX. fig. 9. PLATE XXI. fig. 2.

In this species the labial palpi (pl. xxi, fig. 3) are broad, triangular, with the distal end acute, strongly flattened on the apposed surfaces.

The bases of the outer ones are broadly connected with the mantle lining, and thus enclose the anterior ends of the gills.

Around the mouth are about ten much-branched, unequal, brown, labial tentacles, which are extensively webbed together. Of these, three are at the posterior side of the mouth, one large median one, much divided, and one much smaller one on each side; a large much-divided lateral one lies on each side, at the base of the inner palpus; a still larger and more branched one lies at the base of each outer palpus; three small ones united to the others by a web, lie in front of the mouth. The foot (pl. xx, fig. 9) in alcohol is oblique, stout at base, suddenly contracted at the distal third and again slightly enlarged at the blunt tip. Its anterior face is turned to the right and has a large byssal groove extending to the distal constriction; at the tip there is a very small deep slit, of which the sides can be somewhat expanded; this slit is entirely separate from the byssal groove. In the breeding season the abdomen is prominent and crowded with eggs; it projects downward, and bends abruptly backward, terminating in a small, sharp papilla. Gills four, of the normal fillibranchiate structure. Pallial tentacles very numerous and unequal, the outer ones smaller and much crowded. Ocelli conspicuous; there are generally three between every two of the primary tentacles.

Young specimens (pl. xvi) when 4^{mm} long and 4.5^{mm} high, show an irregular "camptonectes sculpture," together with small and simple radial ribs. The byssal notch is broad and angular, but rounded at bottom; three pectinidial teeth are developed.

Those that are 8^{mm} long and $9{\cdot}5^{mm}$ high have four acute pectinidial teeth, and a broad notch, rounded within. The ribs have become stronger and the edges of the shell are scalloped. The valves gap slightly at the anterior end and at the ends of the auricles. Near the margin, especially of the left valve, concentric sculpture appears, and by crossing the ribs produces a scaly appearance.

Var. *insculpta*, nov.

A variety is occasionally taken on our northern coasts, which has a more elaborate sculpture than usual. The concentric and divergent laminæ and smaller radial riblets cross each other in such a way that a peculiar decussated sculpture is formed between the primary ribs on the early part of the shell, while on the older parts the interspaces are covered with elevated scales. The surface rises into six

or eight broad rounded radial ridges covered, like the interspaces, with rough radial ribs. The sculpture of this variety is figured on pl. xvi, figs. 4–5b. This variety is connected with the common form by intermediate specimens.

This species is found at and just below low-water mark, as well as in deeper water, down to 179 fath., in the Bay of Fundy and northward to Greenland and Iceland, etc. It is common and of large size on the fishing banks off Nova Scotia and Newfoundland. Further south it occurs in 20 to 100 fathoms, as far south as Cape Cod. Dead shells were taken off Martha's Vineyard in 69 to 194 fath.

It is found as a Post-pliocene fossil in Maine, New Brunswick, Canada, Labrador, Greenland and Northern Europe.

Chlamys Benedicti Verrill and Bush, sp. nov.

Shell small, higher than long, with the posterior auricle much longer than the anterior, with a deep byssal notch in the right valve. The dorsal margin is straight and only slightly oblique ; the anterior auricle, in the right valve, is decidedly angular, with its outer end slightly incurved and serrated by the terminations of the radial ribs. The posterior auricle is considerably prolonged and angulated at the upper corner, obtusely rounded at the end and deeply notched where it joins the main shell ; it has four strongly marked radiating ribs, besides the dorso-marginal fold ; below these there is a slightly concave space corresponding to the byssal notch. On the body of the shell there are six or seven sharp serrations along the lower margin of the notch. In the upper valve the posterior auricle is broad and decidedly angular, the dorsal and outer margin forming less than a right angle ; its surface is covered with about five or six radiating ribs decussated by more numerous and finer concentric raised lines, the anterior and posterior margins of the body of the shell slope about equally and form an acute angle ; the ventral margin forms a regular semicircular curve; its entire surface on both valves is covered by strongly raised, rather close radiating ribs, separated by rather wider deep grooves. The interspaces are decussated by regular raised concentric lines ; these are scarcely apparent on the ribs except on very young shells, but there are rather strong elevated spine-like points, especially near the margins, arranged along the ribs in pretty regular concentric lines. These become higher and more pointed anteriorly, and are frequently nearly obsolete in the middle portion of the lower valve ; in that case the ribs appear nearly smooth and rounded. The ribs project at the margin as blunt points,

or serrations. On the inner surface there are radial grooves corresponding to the external ribs. The hinge-margin is thin, with a slender submarginal ligamentary groove and a small triangular resilial pit in the center. The color is variable. The single valve from station 2571 is uniform lemon-color; those from the other locality are chestnut-brown and reddish, variegated with paler, and sometimes with white blotches.

Length of largest specimen, $5{\cdot}5^{mm}$; height, 6^{mm}; length of dorsal margin, 4^{mm}.

Off Martha's Vineyard, in 1356 fath., dead; West Indies, in 25 to 72 fath., living.

This species is allied to *C. varia* of Europe, but when compared with the young of that species, of the same size, the radial ribs are found to be fewer and coarser, and there are other differences which render it probable that they are distinct species. The ribs are stronger and fewer than in *C. Islandica*, and the auricles are different in shape. It is probable, however, that it grows to a much larger size than any of the specimens obtained. It may possibly prove to be the young of some known West Indian species, but does not agree with any known to us.

Chlamys costellata Verrill and Bush, sp. nov.[1]

Shell small, thin, translucent bluish white, covered on both sides with continuous, elevated, and somewhat thickened, well separated radiating riblets, of which there are more than thirty on our largest example. Length of the shell considerably less than the height. Dorsal hinge-margin elongated, especially on the anterior end. In the right valve the anterior auricle is considerably elongated, obtusely rounded or subtruncate at the end, with a wide, angular byssal notch beneath it, and a broad, smooth, angular area next to the body of the shell, above which there are three well marked, angular, radial ridges, separated by wider concave interspaces. Posterior auricle small, triangular, the outer end convex, forming a little more than a right angle and with the posterior margin nearly straight and without any distinct notch.

The dorsal margins of the body of the shell are nearly straight and diverge at less than a right angle. The ventral margin is pretty evenly rounded, but a little produced in the middle. The beak is

[1] Figured in an unpublished paper sent to Proc. U. S. Nat. Mus. several months ago.

small, acute, appressed and does not project beyond the hinge-margin.

The radial ribs are very distinct and clean cut, thickened and rounded at the summit, and separated by nearly smooth intervals two or three times as broad as the ribs themselves. The width of the ribs increases regularly from near the umbos to the margin. A few intermediate ridges commence near the margin.

The left valve is badly broken. It is, however, somewhat more convex than the other, and the radial ribs are crossed by numerous concentric striations, giving them a finely crenulated or beaded appearance. The anterior auricle is broad-triangular, the outer end slightly rounded, and with a slight incurved notch below. It has about six small radial ribs, similar to those of the body of the shell.

Raised lines of growth occur at irregular intervals. Internal surface is smooth and lustrous, and shows the grooves corresponding to the external ribs, and also a very distinct microscopic structure, but is destitute of special radial liræ.

Internally, the hinge-plate is narrow, thin, with a sharply impressed submarginal groove on each end. The resilial pit is excavated in the margin of the hinge itself, and the anterior auricle has internal grooves corresponding to the external ribs.

Length of the largest examples, 6^{mm}; height, $6–5^{mm}$.

Off the coast of Newfoundland in 67 to 72 fathoms.

Chlamys (Æquipecten) glypta Verrill.

Pecten glyptus Verrill, Trans. Conn. Acad., v, p. 580, 1882. Dall, Proc. U. S. Nat. Mus., xii, p. 248, pl. viii, figs. 2, 3, 1889.

Pecten Tryoni Dall, Bullet. Mus. Comp. Zool., xviii, p. 438, 1887 (t. Dall).

Plate XVI. figs. 7–11.

When young this species has strong, well-defined, angular radial ribs of nearly uniform size. In the old shells the grooves are occupied by several small ribs, and a secondary rib develops on each side of the keel of the primary rays; the ribs are all crossed by rather strong concentric sculpture (fig. 8, 11) which is sometimes so coarse as to give both the ribs and grooves a rough appearance. There are about three small, free pectinidial teeth in one of our specimens, but Dr. Dall states that they are absent in his specimen (*P. Tryoni*). It is allied to *C. opercularis* L., of Europe, and to *C. purpurata* of the west coast of South America.

Off the eastern coast of the United States in 69 to 156 fathoms. Off North Carolina in 124 fathoms (Dall). This has been taken only in small numbers, and mostly dead and broken.

Chlamys (Æquipecten) irradians (Lam.)

Pecten irradians Lam., Anim. sans vert., ed. 1, 1819; ed. 2, vol. vii, p 143. Gould, Invert. Mass., ed. 2, p. 199, fig. 496. Verrill, Invert. Vineyard Sd., etc., p. 401 [695], pl. xxxii, fig. 238. Rathbun, Fishing Industries of the U. States, sect. 1, vol. i. p. 509, pl. 255, fig. 8; Ingersoll, op. cit., sect. 5, vol. ii, pp. 565–581, 1887. Jackson, Phylogeny of the Pelecypoda, Mem. Boston Soc. Nat. Hist, vol. iv, pp. 333–350, cut 37, pl. xxvii, fig. 9, pl. xxviii, figs. 1–10, 12, 13, 1890 (young).

Pecten concentricus Say, Journ. Acad. Nat. Sci. Philad., vol. ii, p. 259, 1822.

Plate XVI. fig. 6. Plate XVIII. figs. 1–5. Plate XX. figs. 1–4, 6, 6a.

Some of the young stages of this species have been figured by Mr. Jackson in the work quoted above, and several of his figures have been reproduced on our plate xx (figs. 1–5). We also give new figures of some of the more advanced stages on plate xviii, as well as a figure of the nuclear shell (fig. 1). These figures illustrate well the changes that the young shells undergo. Fig. 2 of pl. xviii shows three successive stages as indicated by prominent lines of growth. Even in the latest of these stages the posterior auricle is but little differentiated, but pectinidial teeth are already developed. This figure also illustrates well the origin of the radial sculpture. No camptonectes sculpture has been noticed at any stage. Radial ribs begin to appear on the right valve when 2^{mm} in diameter, and on the left valve when about $1{\cdot}5^{mm}$.

The transverse incisions of the hinge-plate are usually very distinct in shells less than 20^{mm} in diameter, and often persist in the adult. Occasionally examples are found that show them with unusual distinctness. A specimen in which they are very well developed is figured on pl. xvi, fig. 6. The valves gape a little below the auricles and at the ends of the auricles, to which the tentacles and ocelli extend.

The foot (pl. xx, fig. 6) in alcohol is obliquely turned to the right; it is somewhat enlarged at base, with a deep byssal slit extending about half its length, beyond which it is contracted somewhat, and slightly enlarged at the end, which is divided into two lobes by a short median groove. The labial palpi are broadly triangular, strongly grooved on the apposed surfaces. The oral tentacles are large and consist of numerous contorted lamellæ, much webbed together, and united with the bases of the labial palpi. There appear to be two (or two groups) on each side and somewhat in front of the mouth. The gills are large and of the type usual in this family. The pallial tentacles are very numerous and very unequal in several rows. Two or more of the larger ones correspond to

each rib, while the outer ones are small and much crowded. The ocelli are numerous, unequal in size, the larger ones at first alternate evidently with the primary tentacles and are opposite the external sulci. The ocelli are very brilliant in life.

This species is abundant in shallow water, especially of bays and sounds, from Cape Cod to Florida. It is used extensively as food. The adductor muscle is the only part utilized for this purpose.

Chlamys (Placopecten) Clintonius (Say) Ver. See p. 69.

Pecten Magellanicus? Gmelin, Syst. Nat., p. 3317, 1788, (a bad and misleading name if applied to this species). Lamarck, Anim. sans vert., ed. 2, vii, p. 134. Gould, Invert. Mass., ed. i, p. 132. Dall, Bull. Mus. Comp. Zool., p. 216, 1886.

Pecten Clintonius Say, Journ. Acad. Nat. Sci. Philad., iv, p. 124, pl. 9, fig. 2, 1824. Verrill, Trans. Conn. Acad. Sci., vi, I, p. 261, 1884. Rep. U. S. Com. Fish and Fisheries, for 1883, p. 577.

Pecten tenuicostatus Mighels and Adams, Proc. Boston Soc. Nat. Hist., i, p. 49, 1841; Boston Journ. Nat. Hist., vol. iv, p. 41, pl. 4, fig., 7, 1842 (the young of the smooth variety). Gould, op. cit, ed. 2, p. 196, fig. 494. Verrill, Invert. of Vineyard Sound, etc., p. [696] 402, 1893.

Pecten princeps Emmons, Rep. N. C. Geol. Survey for 1858, p. 280, fig. 198 (fossil form).

Amussium Magellanicum H. and A. Adams, Genera Moll., ii, p. 555, 1858.

Pecten (Pseudamusium) Mülleri Dall, Bull. U. States Nat. Mus., No. 37, p. 34, 1889 (the young).

PLATE XVII. figs. 1–7. PLATE XX. figs. 7–8a. PLATE XXI. figs. 1–1a, 2, 2a.

When very young this species is nearly smooth on both sides, but when about 3–4^{mm} in length, it develops small, regular, raised ribs over the whole surface of the upper valve, and usually at both ends of the lower one, with intervening camptonectes sculpture. (Pl. xvii.)

These small ribs increase in number, but not much in size, until the shell is 2 inches or more in diameter. After that size, in the greater number of shells of the northern variety, they decrease in size till the upper valve becomes nearly smooth, or has only linear riblets. But in some northern examples and in many of those taken in deep water south of Long Island, the small ribs continue regularly over the whole surface of the upper valve, and are more or less roughened by the raised edges of small concentric lamellæ or lines of growth, sometimes becoming more or less finely cancellated. There are no corresponding internal ribs, except in extreme examples of this variety, near the margin, and the edge of the shell is usually only slightly crenulated by the riblets, while the edge of the lower valve is essentially plain and sharp. (Pl. xvii. figs. 5–7.)

This ribbed variety agrees with the fossil form described by Say as *Pecten Clintonius*. For the northern, nearly smooth form, the name given by Mighels (*tenuicostata*) may be retained as a varietal name.

This shell, when full grown, has the margins gaping considerably at both ends, below the auricles, much as in *Amusium*. But the anterior sutural line is less sinuous than in most species, and the byssal notch is small and not excurved.

The gaping is less marked in the young shells, but is evident even in those of small size (pl. xvii, fig. 5). The young shells show three to five pectinidial teeth, but these are usually obsolete in the adult. Transverse incisions on the hinge-plate are evident in the young shells.

The muscular and pallial scars are rather complex and unlike in the two valves (pl. xxi, figs. 2, 2a), but part of them are usually only faintly marked, even in large specimens. The internal surface has a peculiar subnacreous luster and a crystalline structure, somewhat like that often shown on frosted window glass, or that on the surface of tin-plate, after heating.

The large shells, about 6 inches in diameter, still retain the habit of swimming, though often partly covered with barnacles, hydroids, bryozoa, sponges, etc., but they doubtless swim much less actively than do the young ones, which are very lively. Still, I have often seen the large ones leap out of buckets of sea-water in which they had been placed for conveyance. The adults apparently do not ordinarily form a byssus, but there is no evidence that they are unable to do so, if necessary.

The foot of this species (pl. xx, fig. 8) has been described on page 69. The palpi (pl. xxi, figs. 1, 1a) are large and broad, triangular, broadly attached at the bases which run back so as to embrace the anterior ends of the gills; their apposed surfaces are strongly transversely ribbed.

The oral tentacles are very large and complex, arborescently much branched, so that when the branches are contracted in alcohol they appear somewhat like the heads of cauliflowers. The branches are short and crowded and more or less webbed together, while the lateral tentacles are attached by webs to the bases of the palpi. There are five groups or clusters of these tentacles; the two larger pairs are lateral and anterior to the mouth; the odd one, which is similar but rather smaller, is in the median line behind the mouth.

The pallial tentacles and ocelli are very numerous (pl. xx, figs. 7, 8a). The ocelli differ more or less in size; they are separated by

one to three larger, and numerous smaller tentacles. The latter differ greatly in size; the outer ones are small, very numerous, and much crowded. The guard-tentacles (fig. 8a) are shorter, conical, and alternate in two or more rows.

This large species occurs abundantly in many localities off the coast of the United States, north of Cape Hatteras, from just below low-water mark to 60 fathoms, and is sometimes taken below 100 fathoms. It is used as an article of food to a considerable extent in New England.

Hyalopecten dilectus Verrill and Bush, sp. nov.

Shell small, thin, fragile, strongly undulated, slightly oblique, with the ventral margin broadly rounded; dorsal margin straight.

In the right valve, the anterior auricle is elongated, with a deep angular notch beneath; the posterior auricle is shorter, with a prominent dorsal angle, which is less than a right angle, owing to the emargination of the posterior end; in the left valve the anterior auricle is broad, with its posterior angle nearly rectilinear, and it forms a right angle with the dorsal margin; the posterior end has a slightly prominent angle and a posterior emargination in both valves. The anterior auricle is marked by several fine, rough, radial ridges, which are more numerous and stronger on the left valve. The beaks are a little prominent and project somewhat above the dorsal margin.

The surface of both valves is covered with broad and rather regular undulations, most prominent on the left valve; the undulations are crossed by regular, well-spaced, thin, raised radial lines, becoming finer and more crowded at the ends of the shell; they are nearly obsolete in the right valve, being indicated only by microscopic striæ.

The interior is strongly undulated and marked by very distinct radial grooves in the left valve, and by faint ones in the right valve. Resilium small, central; color, dirty white.

Length, 8^{mm}; height, the same.

One living specimen (No. 52,539), from station 2570, off Martha's Vineyard, in 1813 fathoms, 1885.

This species is figured in an article by Verrill and Bush, sent to the Proceedings of the U. S. National Museum, several months ago, but not yet published.

It is closely allied to *P. fragilis* of Jeffreys, and resembles pretty nearly his figure (Proceedings Zoölogical Society of London, plate 45, figure 1), which probably represents a species distinct from the original type described by him. It may be identical with our shell.

Our shell differs decidedly from the original description of *P. fragilis*. Moreover we have obtained from several stations a shell of similar size, which appears to be the true *fragilis*, as it agrees closely with the original description. It also closely resembles *P. pudicus*, described by Mr. Smith, from east of Marion Island, in 1375 fathoms. (Chall. Exp.)

We have but one specimen, which is somewhat broken at the margins.

Hyalopecten fragilis (Jeffreys) Verrill.

Pecten fragilis Jeff., Ann. and Mag. Nat. Hist, 1876, p. 424; Proc. Zool. Soc., London, 1879, p. 561, *pars* (not the fig., pl. 45, fig. 1). Verrill, Trans. Conn. Acad., vi, p. 232, 1885; Expl. by the Albatross, p. 577, 1885.

This is one of the most simple shells known to me in this family.

The shell is very thin, hyaline, distinctly undulated, but not otherwise sculptured. No camptonectes sculpture is visible. The edges are very thin, apparently not bevelled. The hinge-plate is thin and delicate, without cross-lines, and with a single faint submarginal rib, parallel with the margin; ligament very thin; resilium very small, in a triangular pit; no auricular cruræ. The anterior auricle is well developed, with a deep byssal notch, but without pectinidial teeth; the posterior auricle is undeveloped. According to Friele there are no visible ocelli. This species, which we consider the true *P. fragilis* Jeffreys, was taken at the following stations:

Station 2115, in 843 fathoms; 2215, in 578 fath.; 2221, in 1525 fath.; 2234, in 816 fath.; 2710, in 984 fath. It occurs off the European coasts and northward to the Arctic Ocean, in 656 to 1750 fath.

Pseudamusium simile (Laskey).

Pecten similis Lask., Mem. Wern. Soc., i, p. 387, pl. viii, fig. 8, 1811. Forbes and Hanley, Brit. Moll, ii, p. 293, pl. lii, fig. 6, pl. S, fig. 1, animal. Jeffreys, Brit. Conch., ii, p. 71; v, pl. xxiii, fig. 5.

PLATE XVII. figs. 8, 8a.

The shell in this small species is thin, translucent, nearly smooth, symmetrical, broadly rounded, longer than high. The valves are only slightly unequal; the right valve is a little flattened, and its edge turns up a little so as to fit tightly against the edge of the

upper valve. The sculpture, when any is present, is nearly the same on both valves.

The auricles are straight and rather short, the posterior one is broad and obtuse-angled. The byssal notch is small and the pectinidial teeth are obsolete, or nearly so. There are no internal ribs; the inner surface is slightly pearly. The hinge-plate has only one longitudinal rib, just below the ligament; it is crossed by numerous fine, transverse incisions, often more developed than in allied species. The sculpture, when evident, consists of fine lines of growth, and sometimes of very delicate, straight, radial riblets, without camptonectes sculpture.

According to Jeffreys, the ocelli are few in number, about six or eight in the front row and about twice as many in the second row. It swims about for a long time and then quickly anchors itself by a small byssus.

It occurs in 15 to 200 fathoms on the northern European coasts.

Camptonectes Grœnlandica (Sow.) Verrill.

Pecten Grœnlandicus Sowerby, Thes. Conch., p. 57, pl. 13, fig. 40. G. O. Sars, Moll. Reg. Arct. Norveg., p. 23, pl. 2, figs. 4, a–c, 1878.

The shell is rounded, inequivalve, very thin, hyaline, nearly smooth, often with a violet iridescence when fresh. The left valve is covered, even from the nucleus, with fine microscopic camptonectes sculpture, in the form of thin, raised, divergent riblets, more or less irregular and wavy, most visible by translucency. The left valve sometimes has, also, fine radial striæ and delicate lines of growth. The margins are thin and smooth, that of the right valve turns up a little against the other, which is larger, and the valves close very tightly, so that anteriorly there is scarcely any visible gape, even at the byssal notch, or at the end of the auricle. The byssal notch is well-marked and the pectinidial teeth are small and few. The byssus is probably very slender.

The auricles are not oblique and are nearly equal. The hinge-plate is very thin; the single longitudinal ridge is scarcely visible.

A row of six or seven ocelli can be seen through the shell in alcoholic specimens.

Off Newfoundland, in 130 to 224 fathoms. Off northern Europe and in the Arctic Ocean.

Cyclopecten pustulosus Verrill. (See page 70, fig. 1.)

Pecten pustulosus Verrill, Amer. Journal Science, vol. v, p. 14, 1873; Trans. Conn. Acad., vol. iii, p. 50: vol. v, p. 581, pl. 42, figs. 22, 22a; vi, p. 261; Expl. by the Albatross, p. 577, pl. xxxi, figs. 142, *a*, *b*, 1885.

Pecten (*Pseudamusium*) *imbrifer* (*pars*) Dall, Bull. Mus. Comp. Zool., xii, p. 220, 1886 (not the figures), (*non* Loven).

Plate XIX. figs. 3, 4.

In this species the ligament is thin; there is a narrow, simple, cardinal ridge, with faint tranverse denticulations and striæ. The chondrophore is small, excavated in the thickened margin of the hinge-plate in both valves. There are no auricular cruræ.

The nucleus projects above the hinge-margin in the upper valve, but not in the lower. The posterior auricle is small in both valves, but has a prominent outer angle. The byssal notch is small and narrow, with its margin incurved or sinuous; there are no pectinidial teeth. The valves close pretty tightly, leaving only a slight subauricular slit. The inside of the valves often has a subnacreous luster. There is no flattened submarginal area in either valve.

This species has been referred to *Propeamusium Hoskynsi* by Jeffreys, and to *C. imbrifer* by Dall. It never has internal ribs, like the former, which it resembles in sculpture. From the latter, as originally described by Loven, and re-described and figured by G. O. Sars, it differs especially in the character of the ornamentation of the left valve.

The European form has the vesicles much less crowded in each radial row, subconical and mucronate, while in ours they are usually closely crowded and often even in contact in the radial rows; their form is either rounded or elliptical, with the longest diameter in the direction of the concentric lines, and the summit is evenly rounded, showing no tendency to the subconical or mucronate form. When perfect they resemble small blisters with the surface roughened or minutely granular under the microscope; when broken or worn off, as frequently happens, the basal part remains in the form of semi-circular or semi-elliptical, imbricated, arched scales, usually considerably elevated above the surface and connected by very delicate concentric raised lines. The anterior auricle of the left valve is roughened by the close, elevated, concentric lines and by from four to six well-marked radiating ridges or ribs, upon which the concentric lines form regular elevated arched projections, often so crowded as to be imbricated; in some young examples, like the one figured, the concentric lines on the auricle are less crowded, and only two or

three of the radial ribs are developed ; in such examples the vesicles on the body of the shell are relatively fewer, larger, and more rounded and much less crowded in the radial series. In some specimens the posterior margin below the auricle is nearly smooth or marked only by the fine lines of growth, but in others, especially the larger specimens, this region is covered by rather sharp granules, some of which, toward the ventral margin, change to pointed scales in crowded radial rows. The raised concentric lines on the right valve are generally more or less appressed or sometimes imbricated ; toward the ventral margin some of them show very fine microscopic granulations, which are much less distinct than in *P. imbrifer*, as figured by G. O. Sars.

Off the eastern coast of the United States, and northward to Newfoundland, in 99 to 547 fathoms.

This species is evidently distinct from that figured by Dr. Dall (Blake Mollusca, plate 4, figs. 4a, 4b), under the name of *P. imbrifer*. His figured specimen apparently belongs to our *C. subimbrifer*.

Cyclopecten subimbrifer Verrill and Bush, sp. nov. .

Pecten Hoskynsi Verrill, Trans. Conn. Acad., vol. v, p. 581, pl. xliv, fig. 11, 1882 (*non* Forbes).

Shell small, inequivalve, white or grayish white, translucent, length and height nearly equal. Dorsal margin straight ; anterior auricle in the left valve rather large and broad, the outer end obtusely rounded and covered with small, close radial ribs and crowded concentric ridges ; posterior auricle much smaller, with one to three faint radial ridges and many concentric raised lines; outer end forming less than a right angle, with a slight, incurved notch below. In the right valve the anterior auricle has a similar radial sculpture and the byssal notch is rather deep and narrow.

The dorsal outlines of the body of the shell form rather less than a right angle ; the ventral margin forms nearly a semicircle, and forms obtuse angles where it meets the dorsal outlines. Umbos a little prominent, with beaks small, acute, smooth, and projecting beyond the margin of the hinge. The surface of the left valve is covered with slightly raised concentric lines, which are raised into small arched scales ; these are often semicircular, but more frequently somewhat angulated or V-shaped ; they are usually separated by intervals about equal to their breadth. These scales are arranged in about 40 or more radial rows and decrease regularly in size to the umbo, where they are replaced by thin and slightly raised radial

lines, crossing the stronger and more elevated concentric lines, but not rising into points.

The posterior dorsal area, below the auricle, is nearly smooth, except for the fine lines of growth, but sometimes shows minute granules. The right valve, which is smaller than the left, is covered by fine, thin, close, concentric raised lines, which sometimes show microscopic striations.

The anterior auricle is decussated by six to eight or more, small radial ridges, which are crossed by the raised concentric lines; the latter rise into sharp scales at the dorsal margin; the small posterior auricle has fine concentric lines and only two or three faint radial ridges.

Off the eastern coast of the United States; 121 to 312 fath.

The figures of this and various other species were forwarded, several months ago, to the U. S. National Museum, to illustrate an article in its Proceedings.

Cyclopecten leptaleus Verrill.

Pecten leptaleus Verrill, Trans. Conn. Acad., vol. vi, p. 232, 1884; Expl. by the Albatross, p. 577 [75], 1855.

Dr. Dall has expressed a doubt as to whether this species is distinct from *P. imbrifer*. In addition to the original description, it should be stated that the concentric lines are somewhat thickened and elevated, even where thinnest, and that the beaded character is quite unlike anything found in *P. imbrifer* or allied species. The beads are closely arranged, elliptical in form, and most elevated at the center, the elevation being often greater than the diameter; their summits are smooth or glossy, so that when viewed from above, under a lens, each often appears to have a central cavity. The radial lines are comparatively very thin and delicate and not visible except when considerably magnified. The beaks are more acute than in *P. imbrifer*, and the nucleus is smaller and smoother.

Off the eastern coast of the U. States; in 142 fathoms off Cape Hatteras.

Cyclopecten nanus Verrill and Bush, sp. nov.[1]

PLATE XVI. figs. 12–12c.

Shell small, the breadth and height about equal; the valves are nearly equal in size and convexity. Dorsal hinge-margin rather long

[1] Described and figured in an unpublished paper sent to Proc. U. S. Nat. Mus.

and straight; auricles relatively large and broad, both ends subtruncated or a little convex in the left valve, and forming nearly a right angle with the dorsal margin ; anteriorly not well differentiated from the body of the shell. In the right valve the anterior auricle is narrow and somewhat more elongated and obtusely rounded at the end, with a sharp, angular, byssal notch beneath it and separated from the body of the shell by a narrow groove.

The dorsal margins of the body of the shell are nearly straight and form rather more than a right angle. Ventral margin broadly rounded, nearly semi-circular, forming a very obtusely rounded angle where it joins the dorsal margins. Umbos a little prominent, with a small, smooth, rather acute, incurved beak, which usually projects a little above the hinge-margin.

The surface of the left valve is everywhere thickly covered with fine, almost microscopic, radiating striæ, which become a little more distinct on the anterior auricle ; on some parts of the shell very thin, slightly raised, concentric lamellæ or lines of growth are often distinct, especially on the anterior auricle, where they become closer and more regular ; in crossing the radial striations they produce a microscopic decussation, which is often quite regular. The sculpture on the posterior auricle, though finer, is similar, but in many specimens the surface is nearly smooth or marked only by very fine radial striæ. The body of the shell of the right valve is smooth, except for very fine concentric lines; on the anterior auricle are three to six or more distinct radial ridges, which are roughened by conspicuous lines of growth ; the margin below the byssal notch is entire; the posterior auricle is nearly smooth.

The internal hinge-plate is thin in the middle, but relatively broad on each auricle, and is crossed by numerous fine, well marked, transverse incisions ; these are much more conspicuous than in most of the related species, whether young or old. The resilial pit is small, rounded, and situated just under the beak. There are no internal liræ. The inner surface is smooth and glossy, although in fresh specimens the external radiating lines show through by translucency.

The ground-color of the right valve is yellowish or grayish white, with more or less numerous light yellowish brown, or reddish brown spots and blotches, and sometimes with irregular patches of opaque white; right valve white, sometimes with a few yellowish-brown spots. Some specimens are nearly destitute of spots.

The right valve is less convex than the left, and its ventral edge does not quite reach that of the opposite valve; the umbo is less

prominent ; the beak is less acute and scarcely projects beyond, and often falls short of the hinge-margin, but the inequality is less marked than in most of the allied species.

Length of one of the largest specimens 7^{mm} ; height 6^{mm} ; dorsal hinge-margin 4^{mm}.

It was taken in considerable numbers. It is so distinct from all the other species of our coast that a detailed comparison is unnecessary.

Off the eastern coast of the U. States, opposite Chesapeake Bay and Cape Hatteras, in 43 to 132 fathoms. Although very small, this species seems to be adult.

Cyclopecten simplex Verrill, sp. nov.

Plate XVI. fig. 1: Plate XIX. figs. 1, 2.

Shell well rounded, thin, compressed, hyaline. Auricles large, prominent at both ends, unequal, in the right valve the anterior end is considerably prolonged, with a deep byssal notch, and the posterior end is less prolonged with a rather deep emargination or sinus ; in the left valve both ends are shorter and angulated. The left valve is nearly smooth ; the right valve is covered with fine, crowded, concentric, incised lines, and has faint radii on the anterior auricle. Resilial pit small. Transverse incisions of the hinge are fine and vermiculated or irregular.

Height, $4{\cdot}4^{mm}$; breadth about the same. West Indies, U. S. Fish Com.

Propeamusium thalassinum (Dall) Verrill.

Pecten fenestratus Verrill, Proc. U. States Nat. Mus., iii, p 403, 1881 (*non* Forbes).
Amusium fenestratum Verrill, these Trans., v, p. 582, 1882.
Pecten (*Pseudamusium*) *thalassinus* Dall, Bulletin Mus. Comp. Zool., Blake Exp., Pelecypoda, vol. xii, p. 221, 1886.

Plate XIX. figs. 5–7.

This species has been very well described by Dr. Dall[1], but has not been figured.

The larger specimens and some of the young not more than 4 or 5^{mm} in diameter have an internal, raised, opaque white, radial rib, on each end, below the auricles, within the concavity of the shell, and a

[1] Dr. Dall, in the work quoted, has called the upper valve the right and the lower valve the left, and consequently has reversed the anterior and posterior ends, in the descriptions of this and several other species of Pectinidæ. He informs me that this was done inadvertently, and should be corrected.

similar but smaller one, on each end or on the posterior only, above the auricular ridge, forming "auricular cruræ."

In many of the younger shells one or both of the internal ribs may be lacking, as in other species of *Propeamusium*.

The cardinal ridges are rather broad, flat, and crossed by numerous very small transverse incisions and denticles. These are more strongly developed than in many allied species, but less so than in *Cyclopecten nanus* V. and B., and several other species examined. Some examples of *Chlamys irradians* excel in this respect (see pl. xvi, fig. 6).

The resilial pit is peculiar, for in the upper or left valve it projects distinctly beyond the hinge-plate, as a spoon-shaped process, but in the lower valve it is excavated in the sunken and oblique median notch of the hinge margin.

The byssal notch is broad and shallow, its margin not incurved, and without any pectinidial teeth. The auricles are very unequal; the posterior one has a prominent angle.

The upper valve is elegantly cancellated, and often mottled with yellowish white on a reddish ground-color. The lower or right valve is white and covered with strong, even concentric ridges or laminæ. The lower valve has a marginal flattened area which fits closely against a similar, flattened, submarginal area of the upper valve.

Those in alcohol had the soft parts poorly preserved, but there were about six rather distant, black ocelli visible through the translucent shell.

Off the eastern coast of the United States in 43–317 fathoms, West Indies in 84 to 450 fathoms, Blake Exped.

This species is here referred to *Propeamusium* on account of the two internal liræ or ribs within the body of the shell, for the presence of such liræ is the distinctive character of this genus. In other respects it agrees about as well with *Cyclopecten*. These two groups are very much alike in form, sculpture, and the unlikeness of the two valves. The present species is, therefore, intermediate between the typical forms of the two groups.

Analytical Key to the genera of Pectinidæ.

The following table is not strictly a natural one, as to the sequence of the genera, but is as nearly natural as could be made consistently with convenience of use.

MARINE BIOLOGICAL LABORATORY
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I.—Hinge-plate with a central resilial pit.

A.—Hinge-plate without lateral series of marginal pits, resembling resilial pits, but often with small transverse incisions.

A.—Shell with very unequal valves: the right, or lower, valve very convex with a strongly incurved beak; left valve nearly or quite flat, shutting closely inside of the edge of the right valve. Both valves with strong primary radial ribs and internal liræ; edges scalloped. Animal not adapted for swimming.

a. Hinge with the cardinal ribs plain or nearly so. *Pecten* (restr.)

aa. Hinge with the cardinal ribs strongly transversely incised or pitted. *Neithea* (sub-gen.)

AA.—Shell with the valves not very unequal; the upper or left valve the most convex, when any difference exists. Sculpture various. Animal adapted for swimming, at least when young.

B.—Shell internally fluted or smooth, without special radial ribs developed independently of external sculpture.

C.—Hinge-plate with several large distinct, nearly transverse, tooth-like processes. Shell with large external and internal radial ribs. Byssal notch obsolete. *Pallium.*

CC.—Hinge-plate without transverse tooth-like processes. Sculpture various.

D.—Hinge-plate with more than two cardinal ridges, either side of the resilial pit, the lower ones divergent. Radial ribs large and more or less nodose. A distinct byssal notch. *Lyropecten.*

DD.—Hinge-plate with only one or two cardinal ridges, the upper one parallel with the dorsal margin and bounding the ligamental groove; the second, when present, more or less oblique. Sculpture various.

E.—Shell, when adult, permanently attached by the right valve, which is more or less distorted. A deep byssal notch.

b. Right valve directly attached by a shelly deposit. *Hinnites.*

bb. Right valve attached by a modified byssus. *Hemipecten.*

EE.—Shell free through life, or only temporarily attached by a byssus of thread-like fibers. Byssal notch usually present.

F.—One or both valves with external primary ribs or riblets.

a. External ribs small, nearly obsolete on right valve. No internal liræ. Edges of valves not scalloped nor strongly crenulated. *Placopecten.*

aa. External ribs and internal liræ strong; edges of valves scalloped. Byssal notch well developed.

c. Primary radial ribs and internal liræ simple, not increasing with age by forking; shell scarcely oblique. *Æquipecten*

cc. Primary ribs and liræ of various sizes, increasing in numbers with age by forking, or by the interpolation of new ones; auricles or shell usually oblique. *Chlamys* (restr.)

aaa. External and internal ribs simple, formed by corrugations of the shell; internal ribs not thickened. *Leptopecten.*

FF.—Both valves destitute of strong external ribs and internal thickened liræ; edges either smooth or slightly crenulated.

G.—Anterior auricle well developed, with a distinct byssal notch.

d. Valves with the edges simple or slightly crenulated, equal, meeting nearly evenly.

e. Shell swollen, valves strongly convex, nearly smooth, not hyaline; auricles unequal, oblique. *Pectinella.*

ee. Shell compressed, valves little convex, often hyaline.

f. Both valves undulated, and with fine radial sculpture or smooth. Texture hyaline. *Hyalopecten.*

ff. Valves not undulated, sculpture none, or of fine, radial riblets, or cancellated on one or both valves, or vermiculated.

g. Shell nearly smooth, or with small radial riblets; divergent vermiculated sculpture may be present, at least when young. *Pseudamusium* (sens. restr.)

gg. Shell more or less hyaline or translucent; vermiculated divergent sculpture conspicuous when adult, either with or without radial riblets or rows of scales: auricles unequal. *Camptonectes.*

Palliolum.

dd. Valves with the edges smooth and unlike, that of the lower one flattened or bevelled and shutting against the upper one, sculpture on the lower valve consists of concentric raised lines or riblets; on the upper valve of radial riblets, or striæ, lines of scales, or cancellations. *Cyclopecten.*

GG.—Anterior auricle without a byssal notch. Shell thin, rounded, symmetrical.

h. Auricles of one valve, prolonged dorsally in distinct angles or points. *Entolium.*

hh. Auricles not prolonged dorsally; sculpture radial on one valve. *Syncyclonema.*

hhh. Auricles nearly equal, angular, not distinctly prolonged dorsally. Shell very thin, with fine concentric sculpture. *Protamusium.*

BB.—Shell with special internal, radial ribs, independent of external sculpture. Smooth or with delicate sculpture externally; not ribbed. Edges of valves not scalloped. Body of shell usually broadly rounded, not oblique.

i. Shell nearly closed at both ends; texture hyaline; auricles both well developed; byssal notch and pectinidial teeth present.

j. Valves nearly equal; lower valve not concentrically sculptured; both valves with fine radial lines; internal ribs numerous, simple, not differing from the shell in texture. *Lissopecten.*

jj. Valves unequal; lower valve strongly concentrically sculptured; upper valve with radial lines, or rows of scales, or cancellated; internal ribs few, well differentiated from the shell. *Propeamusium.*

ii. Shell large, thin, round and flat, gaping at both ends, usually smooth and polished, but not hyaline; auricles feebly developed; pectinidial teeth and byssal notch obsolete. Internal ribs strong, usually opaque white.

k. Two pairs of gills. *Amusium.*

kk. One pair of gills. *Paramusium.*

AA.—Hinge-plate with a series of definite pits, resembling resilial pits, on each side of the central pit.

l. Auricles small, not well defined. Shell smooth or with fine radial sculpture. *Pernopecten.*

ll. Auricles well developed, angular. Sculpture concentric. *Euchondria.*

II.—Hinge-plate without a central resilial pit.

m. Shell nearly symmetrical. A series of small pits, resembling resilial pits, along the hinge-margin. *Crenipecten.*

mm. Shell oblique, inequilateral, auricles unequal, ligament confined to a groove. *Aviculopecten.*

List of genera, subgenera, and species discussed.

Synonyms are generally omitted. The few included are enclosed in parentheses. Numbers refer to pages; those where special descriptions are given are printed in italics.

Pecten (typical), 43, 44, 53, 54, *56.*

P. maximus, 54, 55, 56; P. dentatus, 57; P. hemicyclicus, 57; P. dubius, 55; P. Jacobæus, 56; P. pictus, 55; P. ziczac, 55; P. atavus, 57.

Neithea, sub. gen., *60.*

P. æquicostatus, 60.

Lyropecten, 49, *63.*

L. nodosus, 63; L. subnodosus, 64; L. corallinoides, 64; L. noduliferus, 64.

Pallium, 51, *59.*

P. plica, 59.

Hinnites, 48, *59.*

H. Cortessi, 59; H. Adamsi, 60; H. pusio, 60.

Hemipecten, 48, *60.*

H. Forbesianus, 60.

Chlamys (typical), 55, *58.*

C. Islandica, 54, 55, 58, *72*, *73;* var. insculpta, 73; C. ornata, 59; C. exasperata, 59; C. costellata, 59, *75;* C. Benedicti, 59, *74;* C. phrygia, 59; C. effluens, 58; C. madreporarum, 49; C. varia, 75.

Æquipecten (sub. gen.), 59, *67.*

C. opercularis, 67; C. irradians, 41, 47, 59, 68, *76* and *77;* C. dislocata, 59, 68; C. glypta, 59, 68, *76;* C. Antillarum, 59, 68; C. nucleus, 68; C. ventricosa, 59, 68; C. purpurata, 68; C. caurina, 68.

Leptopecten (sub. gen.), *69.*

C. Monotimeris, 69.

Lissopecten (sub. gen.), 49, *68.*

C. hyalina, 69.

Placopecten (sub. gen.), 61, *69.*

P. Clintonius, 42, 49, 58, 61, 69, *78;* (*P. magellanica*, 78); var. tenuicostata, 79.

Camptonectes, *62.*

C. lens, 62; C. Grœnlandica, *82.*

Palliolum, sub. gen. or section, *65.*

P. Testæ, 62, 65, *66;* P. striatum, 62, 66; P. tigrinum, 62, 66; P. vitreum, 43, 46, 65, *66.*

Pseudamusium (restr.), *60.*

P. exoticum, 60; P. simile, 46, *81;* P. dispar, 61; P. pseudamusium, 61; (P. glabrum, 61; P. hyalinum, 61; P. corneum, 61; P. natans, 61; P. tigrinum, 61).

Pectinella, *68.*

P. Sigsbei, 68.

Hyalopecten, 63, *71.*

H. undatus, 63, 71; H. dilectus, 62, 71, *80;* H. fragilis, 63, 71, 80, *81;* H. pudicus, 63, 71, 81.

Syncyclonema, *62.*

P. rigida, 62.

Cyclopecten, 61, *70.*

C. pustulosus, 70, *82;* C. imbrifer, 70, *83;* C. subimbrifer, 70, *84;* C. leptaleus, 70, *85;* C. nanus, 70, *85;* C. reticulus, 71; C. simplex, 70; C. Culebrensis, 70; C. Murrayi, 71; C. clathratus, 71; C. subhyalinus, 71; C. distinctus, 71; C. Kermadeciensis, 71; C. orbicularis, p. 71.

Propeamusium, *64.*

P. inequisculpta, 64; P. thalassinum, 65, *87;* P. Pourtalesianum, 65; P. cancellatum, 65; P. Sayanum, 65; P. Holmesii, 65; P. Alaskensis, 65; P. Hoskynsi, 65; P. lucidum, 65; P. scitulum, 65; P. Torresi, 65; P. propinquum, 65; P. obliquum, 65.

Amusium, 42, 49, 55, *57.*

A. pleuronectes, 55, 58; A. Mortoni, 57, 58; A. Japonicum, 58; A. Laurentii, 55; (A. Dalli, 57, 58).

Paramusium, 52, *57, 72.*

P. Dalli, 52, 72.

Protamusium 62, *71, 73.*

P. demissum, 72; P. disciforme, 72; P. membranaceum, 72; P. illustre, 72; P. sulcatellum, 72; P. obovatum, 72.

Entolium, *62.*

E. cornutum, 62.

Pernopecten, *63.*

P. limiformis, 63.

Euchondria, *64.*

E. neglecta, 64.

Crenipecten, *65.*

C. crenulatus, 65.

Aviculopecten, *60.*

A. concavus, 60.

EXPLANATION OF PLATES.

All the drawings on the following plates were made from nature by Mr. A. Hyatt Verrill, except figs. 5 and 6 of pl. xviii, and fig. 7 of pl. xix, which were drawn by J. H. Emerton, and figures 1–5 of pl. xix, which are copied from Dr. R. T. Jackson.

PLATE XVI.

Figure 1.—*Cyclopecten simplex* V., sp. nov. Right valve, × 15.

Figure 2.—*Chlamys Islandica*, young. Left valve, × 8.

Figure 3.—The same, somewhat older. Right valve, × about 5 diameters.

Figure 4.—The same, var. *insculpta*, portion of the surface, near the margin, × 15.

Figure 5, 5*a*.—The same variety. Portions of the sculpture of the disk of a young specimen, × 20.

Figure 5*b*.—The same specimen. Portion of the sculpture nearer the umbo, × 40.

Figure 6.—*Chlamys irradians*. Part of hinge to show the transverse incisions (*i*), the ligament (*l*), the resilial pit (*r*), and the cardinal ribs (*t*), × 4.

Figure 7.—*Chlamys glypta* V. Inside of left valve, × 3

Figure 8.—The same. Upper part of right valve of a larger specimen; *p*, pectinidial teeth, × 4.

Figure 9.—The same. Hinge of a small specimen, right valve; *c*, crural rib; *d*, crural denticle; *l*, ligament; *i*, cardinal ribs and transverse incisions; *p*, pectinidial teeth and byssal notch; *r*, resilial pit, × 4.

Figure 10.—The same. Two of the internal bicarinate radial ribs, at the margin, × 4.

Figure 11.—The same. Sculpture of a large specimen close to the margin, × 8.

Figure 12.—*Cyclopecten parvus* V. and Bush. Right valve, × 8.

Figure 12*a*.—The same. Hinge of left valve, × 15.

Figure 12*b*.—The same. Sculpture of the left valve near the umbo, × 100.

Figure 12*c*.—The same. Sculpture of the left valve near the margin, × 100.

PLATE XVII.

Figure 1.—*Chlamys* (*Placopecten*) *Clintonius*, young, left valve, × 8.

Figure 2.—The same, somewhat older, right valve, × 6.

Figure 3.—The same, slightly older, interior of right valve, × 6.

Figure 4.—The same. Hinge of right valve of a more mature example, × 3.

Figure 5.—The same, young. End view of posterior end of a specimen showing unusually large riblets. To illustrate extent of gaping and inequality of the valves, × 9.

Figure 6.—The same. A portion of the sculpture of the left valve of an unusually strongly sculptured example. × 15.

Figure 7.—The same. Portion of the sculpture from near the margin of the left valve of another young specimen, showing the camptonectes sculpture, × 24; 7*a*, 7*b*, other parts of the same valve more enlarged.

Figure 8.—*Pseudamusium simile*. Left valve, × 6.

Figure 8*a*.—The same. Right valve, × 6.

Plate XVIII.

Figure 1.—*Chlamys irradians.* Nuclear region of a young specimen showing the prodissoconch, or veliger shell, × 60.

Figure 2.—The same. Right side of a very young shell, × 15.

Figure 3.—The same. Right side of a somewhat larger specimen, showing two stages of growth, × 6.

Figure 4.—The same. Left side of a similar young specimen, × 6.

Figure 5.—*Hyalopecten undatus.* Left valve of the type-specimen, × 1½. By J. H. Emerton. (See Trans. Conn. Acad., vi, p. 444.)

Figure 6.—*Camptonectes* (*Palliolum*) *vitrea.* Right side of a mature specimen. By J. H. Emerton.

Figure 7.—The same. Hinge of right valve, × 6.

Figure 8.—The same. Hinge of left valve of the same specimen, × 6.

Figure 9, 9*a*.—The same. Sculpture of the left valve of a perfect specimen, × 27.

Figure 10.—The same. Right side of a very young specimen, × 16.

Figure 11.—The same. Left side of a somewhat larger example, × 12.

Figures 12, 12*a*.—Dorsal views of the right and left valves of the nuclear shell of a small specimen, × 60.

Figure 13.—The same. Side view of the nuclear shell, × 60.

Figure 14.—*Camptonectes* (*Palliolum*) *striata.* Inside of right valve, × 6.

Figure 14*a*.—The same. Sculpture of the left valve, × 24.

Plate XIX.

Figure 1.—*Cyclopecten simplex* Ver. (sp. nov.). Interior of left valve, × 15.

Figure 2.—The same. Interior of right valve, × 15.

Figure 3.—*Cyclopecten pustulosus.* Right side of a young specimen, showing the nuclear shell, × 12.

Figure 4.—The same. Left side of a slightly older specimen, × 12.

Figure 5.—*Propeamusium thalassinum.* Left side, × 12.

Figure 6.—The same. Interior of a right valve, × 9.

Figure 7.—The same. Hinge of left valve of the same example, × 9.

Figure 8.—*Propeamusium inequisculpta.* Interior of a left valve, × 8.

Figure 8*a*.—The same. Sculpture of the left valve, × 15.

Figure 9.—The same. Interior of a right valve of a young specimen showing the beginning of the internal ribs, × 9.

Plate XX.

Figure 1.—*Chlamys irradians.* Very young spat, much enlarged; *p*, nuclear or veliger shell; *f*, foot; *g*, rudimentary gill; *h*, heart; *ad*, adductor muscle; *a*, anus; *m*, mantle; *e*, ocelli; *t*, tentacles. After Jackson.

Figure 2.—The same. Left side of a very young living specimen, much enlarged; *f*, foot; *x*, an opening through which water was ejected, showing an unusual protrusion of the mantle border (perhaps accidental).

Figure 3.—The same. Right side of a very young shell, much enlarged; *n*. byssal notch and first pectinidial tooth; *p*, *p*, prodissoconch or nuclear shell.

Figure 4.—The same. Diagramatic view of gill-filament of adult; *a*, direct border; *a'*, reflected border; *s*, septum uniting the two parts of about every fifteenth filament; *bl*, blade.

Figure 5.—The same. Diagram of section through shell (*s*) and adductor muscle (*ad*); *l*, resilium; *m*, mantle; *mw*, guard or inner reflected edge of mantle; *gt*, guard tentacles; *t*, marginal or pallial tentacles; *e*, ocelli.

Figure 6.—The same. View of the interior when the shell and mantles are spread open; about twice natural size; *a*, mouth; *b*, rectum and anus; *c*, abdominal mass; *d*, labial palpi; *e*, oral tentacles; *f*, foot; *g*, inner gill, showing reflexed margin; *m*, inner surface of mantle; *m'*, its reflexed inner margin or guard, and guard tentacles. From an alcoholic specimen.

Figure 6*a*.—The same. Portion of the mantle margin more enlarged: *o*, *o'*, primary and secondary ocelli; *t*, *t'*, primary and secondary tentacles.

Figure 7.—*Chlamys* (*Placopecten*) *Clintonius*. Front view of a small living and active specimen about one-half natural size; *m*, inner mantle margin or guard.

Figure 8.—The same. Foot of a larger alcoholic specimen, × 2; *r*, byssal groove; *s*, terminal bilobed disk.

Figure 8*a*.—The same. Portion of the mantle-margin of an alcoholic specimen, × 4; *m*, inner surface of mantle, showing blood spaces and nerves; *m'*, reflexed inner margin; *m''*, guard tentacles; *t*, marginal pallial tentacles; *o*, ocelli.

Figure 9.—*Chlamys Islandica*. The foot of an alcoholic specimen, × 6; *r*, byssal groove; *s*, terminal slit or groove.

Figures 1–5 of this plate are copied from Dr. Jackson; fig. 7 was drawn by J. H. Emerton; the rest are by A. Hyatt Verrill.

Plate XXI.

Figure 1.—*Chlamys* (*Placopecten*) *Clintonius*. Part of animal of an alcoholic specimen, × 6; *a*, mouth; *e*, oral tentacles; *d*, *d'*, outer and inner labial palpi; *g*, anterior end of gill.

Figure 1*a*.—The same, a part of one of the oral tentacles, more enlarged, to show mode of branching.

Figures 2, 2*a*.—The same. Right and left valves showing muscular scars, ⅔ natural size; *a*, *a*, scars of adductor; *a'*, portion of adductor with finer fibers; *b*, pallial line; *c*, row of small pallial scars, of irregular occurrence; *d*, *d*, more or less lobed dorsal margin of adductor scar; the pedal muscle is attached obliquely to the adductor muscle of the left valve at *d*, in fig. 2*a*; *e*, *e'*, special pallial muscles below the auricles (subauricular muscles), situated in the region where the pallial guard become narrow and the guard-tentacles obsolete; *n*, byssal notch; *l*, ligament; *t*, transverse cardinal rib; *r*, resilium.

Figure 3.—*Chlamys Islandica*. Part of animal, × 6; *a*, mouth; *e*, oral tentacles; *d*, *d'*, outer and inner labial palpi; *g*, anterior end of gill; *r*, byssal groove of foot; *s*, terminal slit of foot.

Figure 4.—*Pallium plica*. Hinge of right valve, × 5.

ADDENDA AND ERRATUM.

The two following groups were omitted from their proper places in the list of divisions that have been proposed :

Leptochrondria Bittner, 1891. Type, *P.* (*L.*) *œolicus* from the Trias of Asia Minor. Proposed as a subgenus of *Pecten*.

Deltopecten Morris, 1892. Type, *D. Illawarensis* M., from the Permo-carboniferous of Queensland. Described as intermediate between *Pecten* and *Aviculopecten*.

Page 78, line 22. For *Mulleri* read *striatus*.

III.—Revision of the Marine Gastropods referred to Cyclostrema, Adeorbis, Vitrinella, and related genera; with descriptions of some new genera and species belonging to the Atlantic Fauna of America. By Katharine Jeannette Bush.

In studying the descriptions and figures of the many species of marine gastropods from various and widely separated localities, which have been referred to *Cyclostrema*, *Adeorbis*, *Vitrinella*, and related genera, I soon found that there was great variation in their form, texture and sculpture. It seemed to me that the most satisfactory and permanent results toward eliminating this confusion would be gained by publishing the original descriptions of the various genera, with their types, for convenience in deciding the relations of the species already known.

In the present article, therefore, I have given descriptions of the genera, arranged chronologically, with lists of the species belonging to the marine fauna of eastern America, which have been correctly or incorrectly referred to them, together with several new genera and species. When possible, I have also given figures of the type species of each genus.

In carrying on these investigations I have been greatly aided by Professor A. E. Verrill, of Yale University, Dr. W. H. Dall, of the U. S. National Museum, and Mr. E. A. Smith, of the British Museum.

Cyclostrema Marryatt, 1818. Type, *C. cancellata* Marryatt. West Indies?

Plate XXII. figs. 4, 4*a*.

"*Cyclostrema*."

"Character genericus."

"Testa depressa, perspectivo-umbilicata; apertura circularis."

"*C. cancellata* Marryatt."

"Tab. x, Figs. 3, 4."

"C. testa alba, lineis longitudinalibus et transversis elevatis decussantibus, inde cancellata. Habitat ——."

"Apertura labiis cancellatis, cancellis tranversim striatis."

"I found this beautiful little shell among a collection of chiefly West Indian Shells. According to the Linnæan system, it would come under the genus *Turbo*," etc., etc. Trans. Linn. Soc. London, xii, p. 338, 1818.

These inadequate descriptions and want of knowledge of the operculum, animal and odontophore of the type, together with the fact that Marryatt stated that *Helix depressa* and *Helix serpuloides* were referable to the same genus, have doubtless led to the greater part of the confusion into which the genus has fallen.

As its true position cannot at present be decided, it seems best to follow the authors who have studied similar species. S. P. Woodward (1851-6) placed the genus in the family Turbinidæ, with *Liotia* Gray (1850), and *Collonia* Gray (1850), as subgenera of *Delphinula* (Roissy) Lam. The figure he gives as *cancellata*, however, does not agree very closely with those of Marryatt and the locality of the species is given as the Philippines. H. and A. Adams (1858) placed it next *Liotia* in the family Liotiinæ and added two subgenera, *Cynisca* H. and A. Adams and *Serpularia* Römer, 1843 (? *Spira* Brown, 1838). See pages 107, 108. The original figure that is given as *cancellata*, however, represents a very different species, as do also those given by Chenu in his Manual, and by A. Adams in Sowerby's Thes. Conch., copied by Tryon.

The following extract from a letter from Mr. E. A. Smith, of the British Museum, under the date of May 7th, corroborates this opinion.

" The shell figured by H. and A. Adams (Gen. Rec. Moll., pl. xlv, f. 6*a*. and in Sowerby's Thesaurus, iii, pl. 255, figs. 5, 6), in my opinion is perfectly distinct from Marryatt's *Cyclostrema cancellata*, and I have long ago noted this.

Kiener's *Delphinula cancellata* (Icon. Coq. Viv., p. 10, pl. iv, f. 10) = *Kieneri* Phil. is, I consider, Marryatt's species. It is curious that both employed the same specific name. I do not know that the shell figured by Adams has been renamed," etc.

The only reference that I have found regarding this difference is in Tryon's Manual, x, p. 89, 1888, where it is suggested that the Philippine specimens, as figured by Sowerby, may prove to be identical with *Cyclostrema eburnea* Nevill, from the Bay of Bengal. The figures 27–30, as given on pl. 31, look very unlike, and I very much doubt the accuracy of such a combination. For the species figured as *C. cancellata* by H. and A. Adams and copied by Chenu, I propose the specific name *pseudocancellata*. I very seriously question its rightful reference to the genus *Cyclostrema*, however, but such a question must be left to the future study of the authentic specimens. Whether or not the description given by A. Adams, P. Z. S., p. 41, February, 1850, refers to the same species that is

figured, is also an open question. Tryon's copies of Sowerby's figures do not agree perfectly with the figure in Gen. Rec. Moll., and I am unable to consult the original ones.

The numerous small, rather thin, nearly smooth species from deep-water which have been referred to *Cyclostrema* by several authors, belong to several quite distinct genera. These have few convex whorls, forming a moderately elevated spire; the aperture circular, not modified, as in *affine* Verrill = *proxima* Tryon, or nearly circular and modified on the body-whorl, as in *Dalli* Verrill; the peritreme simple, entire, or more or less modified; and the umbilicus deep, but varying from one of moderate size to a scarcely perceptible chink.

Much careful study of the other numerous and varied forms, which have also been erroneously referred to the genus, is necessary before their true position can be determined.

The family name Cyclostrematidæ, constituted by Fischer, should now be restricted to forms like the true *C. cancellata* Marryatt, and perhaps may prove to be closely related to, or synonymous with, Liotiinæ (Adams and Chenu), Liotiidæ (Tryon), or Delphinulidæ (Fischer and Dall).

The following extract from a letter from Dr. Dall, of the U. S. National Museum, under the date of April 14th, shows the possible relation of the genus.

"I had never looked up Marryatt's original figures before, but took this occasion for doing so. What he had was, it seems to me, a *Solariorbis* (as I have been calling them) very much like some I have been describing from the southern Miocene and Pliocene," etc.

List of species belonging to the marine fauna of eastern America which have been referred to *Cyclostrema:*

Cyclostrema cancellata Marryatt, *C. Schrammii* Fischer, *C. Beauii* (Fischer) Tryon = *C. bicarinatum* Guppy, *C. angulata* A. Adams, *C. Dalli* Verrill (*non C. fulgidum* (Jeffreys, 1883) Dall), and variety *ornatum* Verrill, *C. cingulatum* Verrill = *C. Verrilli* Tryon, *C. affine* Verrill = *C. proxima* Tryon (*non C. trochoides* (Jeffreys MSS.) Sars.), *C. diaphanum* Verrill, *C. valvatoides* Jeffreys, *C.* (*Granigyra*) *limata* Dall, *C. turbinum* Dall, *C. pompholyx* Dall, *C. cistronium* Dall, *C. granulum* Dall, *C. cancellatum* (Jeffreys) Dall (*non* Marryatt), *C. tuberculosa* (d'Orbigny) Tryon, *C. excavata* Watson = *C. subexcavata* Tryon, *C. diaphana* (d'Orb.) Poulsen (*non* Verrill).

Delphinoidea Brown, 1827. Type, *D. serpuloides* (Montagu). Devonshire coast, England.

PLATE XXII. figs. 1–1*b*.

"Spire depressed, surface smooth, divested of spinous processes; aperture orbicular, or nearly so, and not enveloping the body volution." Ill. Cat. Gt. Britain, p. 19, 1838? (2d ed.)

This genus has been considered by most authors as a synonym of *Cyclostrema*, but the very small, nearly smooth species referred to it by Brown are very unlike the highly sculptured type of that genus.

Even as restricted and described in the 2d ed. this is a heterogenous genus without a designated type, with two subdivisions (I.—Volutions Dextral. II.—Volutions Sinistral), containing in all four described and figured species, in the following order:

1. *D. unispiralis* (Montagu). 2. *D. depressa* (Montagu). 3. *D. serpuloides* (Montagu), and 4. *D. resupinata* (Montagu). The last being the only representative of the second subdivision.

These with several other of Montagu's species of *Helix* were included under *Delphinoidea* in the 1st ed., 1827. The first species, *unispiralis*, is described by Brown as follows:

"Shell glossy white and opaque, with one volution, umbilicate on both sides; aperture circular. Diameter scarce a line."

"Found at Sandwich, and is very rare."

This was without doubt a veliger shell, the true specific relations of which it is impossible to determine without comparing it with similar species from the same region.

Fleming, in 1828[1] (Hist. Brit. An.), constituted the genus *Skenea* and referred *depressa* Montagu, and *serpuloides* Montagu, to it. In the 2d ed. Brown restored these two species to his genus *Delphinoidea* and gave references to Fleming's article. *Helix depressus* Montagu is now considered the same as *Skenea planorbis* (Fabricius),[2] which stands as the type of *Skenea*. See plate xxiii, figs. 5, 8, 8*a*.

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[1] Gray, P. Z. S., 1847, p. 152, gives 1824.

[2] *Skenea planorbis* (Fabricius) is common on the rocky shores of our eastern coast from Long Island to Greenland. It is a minute shell without sculpture, covered with a conspicuous amber or delicate horn-colored epidermis, of about three well-rounded whorls, with deep sutures, coiled nearly in the same plane so that the spire is but little elevated. The umbilicus is large, revealing all the whorls, with rounded walls. Aperture circular; peritreme simple, continuous. Operculum thin, of a delicate horn-color, circular, with central nucleus of about six whorls defined by an indistinct spiral line. Radula with a series of seven unequal, distinctly serrate, curved teeth in each row. For figures see G. O. Sars, Moll. Reg. Arct. Norv., pl. vi, f. 15; pl. xviii, f. 23, 1878.

The animal of *serpuloides* was carefully studied and described by Wm. Clark in 1855 (Brit. Mar. Test. Moll.), and the species was placed by him in the genus *Trochus*. A figure of it was given by H. and A. Adams in 1858 (Gen. Rec. Moll.), under the name *Cyclostrema serpuloides*, but these authors stated that "Should the smaller British species require to be separated from the more typical forms they will take the name of *Delphinoidea* Brown." Jeffreys, in 1865 (Brit. Conc., iii.), described and figured it as *Cyclostrema serpuloides* because "*Delphinoidea* is both superfluous and heterogenous." This decided statement has doubtless been the cause of much of the misunderstanding of *Cyclostrema* of more recent authors. G. O. Sars in 1878 (Reg. Moll. Arc. Norv.), restored the species to *Delphinoidea*, but described and figured the young of *Margarita helicina* (Fab.) as *serpuloides* (Supl., p. 346).

Delphinoidea is unquestionably a very unfortunate selection for a generic name, as it is used to designate an ordinal group of Dolphins, etc.

Delphinoidea Brown (sens. restr.).

Shell small, white, consisting of a few convex whorls coiled nearly in the same plane so that the spire is but little raised; suture deep; umbilicus rather large, deep, with rounded walls, showing all the whorls, and not defined by a carina; aperture oblique, nearly circular, slightly angulated above, not modified by the body-whorl; peritreme simple, thin, entire, but slightly attached; columellar edge very slightly or not at all flattened.

Type, *D. serpuloides* (Montagu). Described and figured by Jeffreys, B. C., iii, p. 290, pl. vii, f. 3.

Specimens (No. 9450) from Guernsey, England, in the Yale Museum, presented by the Rev. Canon A. M. Norman, measure about 1·5^{mm} in diameter. They are rather thin, white, somewhat shining, of about three convex whorls, forming a very low spire with deep sutures. Very fine microscopic, raised, revolving lines commence on the periphery of the whorls; these become more conspicuous and widely separated on the base and umbilical region. The aperture is nearly circular, with a slight angle where it touches the body-whorl. The peritreme is simple, continuous, but along the columellar margin the edge seems slightly flattened. Some specimens have a delicate raised line just within the aperture.

H. serpuloides Montagu is given by Fischer as an example of the section *Daronia* under his Cyclostrematidæ. I place it with the Vitrinellidæ.

The species described and figured by G. O. Sars (p. 345, pl. 34, figs. 6*a*–6*d*), as *Cyclostrema areolatum*, seems to me a true *Delphinoidea*.

Adeorbis S. V. Wood, 1842. Type, *A. subcarinatus* (Montagu). South coast of Devon.

PLATE XXII. figs. 5, 9.

Mr. Searles V. Wood, in 1842, in his "Catalogue of the Crag Mollusca," published in the Annals and Magazine of Natural History, London, ix, proposed the genus *Adeorbis* for a group of small shells which he characterized as follows :

"Whorls subdiscoidal, volutions few, peritreme sharp, inner lip sinuous, umbilicus large and deep."

He failed to mention a type species as such, but described and figured *A. striatus* Wood, alone of the five species which he referred to the genus, only naming the other four, all of which are new, except *A. subcarinatus* (Montagu), which is placed as fourth in the list. In 1848, in his "Monograph on the Crag Mollusca," he redefined the genus as follows :

"Shell generally small, suborbicular, depressed, with a few nearly discoidal and rapidly increasing volutions, umbilicus large and deep; peritreme entire and nearly continuous, slightly interrupted by the previous volution, deeply sinuated on the inner side, having a minute or incipient sinus at the upper part of the aperture near the junction of body-whorl."

Although comparing the genus with *Skenea* he placed it next to *Margarita*. He again failed to mention a type species, but placed *A. striatus* Wood first, as before, and described and figured four other species, omitting *A. subimbricatus*, which in 1842 he included in the genus with a mark of doubt, and added *A. pulchralis* Wood, which in 1842 he had identified as *Margarita helicina* Wood. He also mentioned that his *A. striatus* is probably the same as *Valvata striata* of Philippi.

Mr. S. P. Woodward in his "Manual of Conchology," published in 1851–6, defined *Adeorbis* and mentioned and figured as the type, *A. subcarinatus* (Montagu), placing it next to *Cyclostrema*, as a subgenus of *Delphinula*.

H. and A. Adams, in 1858, in their "Genera of Recent Mollusca,"

defined the genus and figured *A. subcarinatus* (Mont.) as an example, placing it next to *Cyclostrema*.

Chenu, in 1859, defined the genus, mentioning and figuring *A. subcarinatus* (Montagu) as an example, adding also figures of *A. striatus* Wood.

Mr. Jeffreys, in 1865, seems to have been the first author to make any generic distinction between the several species of Wood. In "British Conchology," vol. iii, p. 315, he described as *Trochus Duminyi* Requien, a recent shell found at Bonegal Bay, identifying it as *Delphinula Duminyi* Requien, 1848 = *Adeorbis striatus* Wood, 1848 = *Valvata? striata* Philippi, 1836, and mentioning *A. supranitidus* Wood, and *A. tricarinatus* Wood, as fossil varieties. The specific name *striata* had been preoccupied by *Trochus striata* Linné. He made a special section under the genus *Trochus* for the reception of such forms, as "they are very distinct from the typical *Adeorbis subcarinatus* (Montagu), the operculum of which is paucispiral and horny, with lateral nucleus." The section is defined as follows :

"C. Very small, circular, nearly flat-spired with exceedingly wide and open umbilicus. *Circulus.*" See p. 110.

He mentioned that the animal of *Duminyi* is unknown, but described the operculum as follows :

"Operculum circular with about a dozen volutions which wind spirally and gradually and converge to the centre." A very poor figure of the species is given in vol. v, pl. 62, fig. 5.

Fischer, in his "Manuel de Conchyliologie," defined *Adeorbis*, and stated that the operculum is horny, spiral and excentric, giving and figuring *A. subcarinatus* as the type.

Tryon, in his "Manual of Conchology," 1883, defined the genus, mentioning and figuring *A. subcarinatus* (Mont.) as an example, but stated that the operculum is "shelly, subspiral."

There is little doubt that Wood intended *A. striatus* to stand as the type, but, as he included three quite distinct forms in the genus and failed to mention a type species, according to definite rules of nomenclature, the type given by the author who first separates the species of the genus has to stand as the one to be adopted.

A. subcarinatus (Mont.), of which I have several examples (No. 9428) before me, collected at Guernsey, England, and presented to the Museum by the Rev. Canon A. M. Norman, is a very small (the largest is about $2{\cdot}5^{mm}$ in diameter), moderately thick, white shell, of about three abruptly enlarging whorls, so coiled that the suture ends at the periphery of the preceding whorl. The whorls are well

rounded above but decidedly angular below, with the base flat and appearing somewhat concave. The umbilical region is of considerable size, with a comparatively small but deep opening, which is not in the center of the base, owing to the abrupt enlargement of the whorls. The aperture is large, very oblique, somewhat angular, so that when the shell rests on the base the spire is considerably tilted. The sculpture consists, on the body-whorl, of four to six unevenly elevated, unequally separated carinæ, which are crossed by very conspicuous, elevated, irregular, oblique, somewhat sinuous lines in the direction of the lines of growth ; these considerably roughen the entire surface from the suture over the base well up into the umbilicus. The suture is defined by a much roughened carina which rests well up on the preceding whorl. The nucleus is regularly coiled, smooth and shining. Some specimens are very glassy and some are stained by oxide of iron.

Nothing seemed to be known of the animal or operculum until 1865, when Mr. Jeffreys described the latter (B. C., vol. iii, p. 317) as "paucispiral, horny, with lateral nucleus," and suggested the near relation of the genus to *Solarium*. In 1869 (B. C., vol. v, p. 216), he mentioned a specimen as having been found with the animal which is of a very red color. In 1885 ("Proceedings of the Zoölogical Society" of London, for January, p. 40), he again mentioned the animal and referred to the descriptions given by Mr. Duprey in the "Annals and Magazine of Natural History," London, for October, 1876. Mr. Duprey stated that he had had several animals alive for some time and had studied their habits and characters with great care. The following is an abstract of his description :

Animal white, with a pinkish hue, semi-transparent, easily contained in the shell. Snout rather long, extensile, cloven at the tip. Tentacles long, extensile, blunt, diverging. Eyes very small, at outward base and a little behind the tentacles. Foot slightly notched in front, square behind. Gill comblike, on right side of body.

Unfortunately the odontophore of the type has never been studied, so that the true relation of the genus is still doubtful.

List of species belonging to the marine fauna of eastern America which have been referred to *Adeorbis:*

Adeorbis Beauii Fischer, *A. Orbignyi* Fischer, *A. Adamsi* Fischer, *A. lirata* (Verrill) Dall, *A. supranitidus* Wood = *A. trilix* (Bush) Dall, *A. striatus* Wood = sp. ?, *A. elegans* A. Adams, *A.* (*Clathrella*) *naticoides* Dall, *A. nautiliformis* Holmes = *Cochliolepis parasitica* Stimpson, *A. olivaceus* (Verrill) Dall, *A. costulata* (Möller) Verrill = *Mölleria costulata* (Möller) Jeffreys, *A. inornatum* (d'Orb.), *A. cyclostomoides* Pfr.

Separatista Gray, 1847 (not described), A. Adams, 1850. Type, *S. separatista* (Chem.) Dillw. = *S. Chemnitzii* A. Adams. Philippines.

"Shell orbicular, somewhat discoid, the first whorls contiguous, the last disunited; aperture wide-spreading, angulated; umbilicus large, infundibuliform, the whorls visible within as far as the apex." P. Z. S., p. 45, 1850.

Two species were described, *S. Grayii* Ad., from the Cape of Good Hope; and *S. Chemnitzii* Ad., from the Philippines, which was figured by H. and A. Adams, 1858, and is considered as the type of the genus.

The following extract from a letter from Dr. Dall, under the date of April 23d, explains the apparent confusion in the names which have been applied to the type:

"Gray's *Separatista* was founded on *Turbo separatista* of Chemn. (x, figs. 1589–90), which was named *S. chemnitzii* by Adams (1850), who adds a second species *S. Grayi*. Gray (P. Z. S., 1847, p. 136) cites *Turbo helicinus* Gmel., as a name for the former, but this was a *lapsus pennæ* for *T. helicoides* Gmelin, who had, however, another *T. helicoides*, so that this one will retain the name of (*Turbo*) *separatista* applied to it by Dillwyn (1817), to which Adams' name will fall in synonymy."

As nothing is known of the operculum or soft parts, the true position is very doubtful. H. and A. Adams placed it in the subfamily Rapaninæ; Fischer, as a questionable subgenus of *Trichotropis*, but Mr. Dall, who states that he has examined the type in the British Museum, placed it in the family ? Adeorbidæ. He constituted a new section *Haloceras*[1] for *Separatista cingulata* (V.) Dall, the young or immature form of which was described by Prof. Verrill as *Cithna cingulata*. The family Adeorbidæ can, however, only be applicable to the genus *Adeorbis* and related forms, whose true position is undeterminable until the odontophore of the type, *subcarinatus*, can be studied.

Vitrinella C. B. Adams, 1850. Type, *V. helicoidea* C. B. Adams. Jamaica.

Plate XXIII. figs. 9, 9*a*.

"Shell turbiniform, vitreous, minute, with a large orbicular aperture, either umbilicated or with the umbilical region deeply and widely indented."

[1] Bull. Mus. Comp. Zoöl., xviii, p. 277, 1889.

"The form of the aperture would place these shells in *Turbo* or *Margarita*. The want of an umbilicus excludes three of the species from the latter. The operculum is unknown ; but as it is extremely improbable that thin, vitreous, almost transparent shells should have solid calcareous opercula, we may assume it to be horny, which will exclude the species from *Turbo*, regarding this genus as best characterized by the operculum. The most widely umbilicated species approximates in form to *Skenea*, and might be mistaken for a depressed umbilicated species of *Helix*. In texture, the nearest approach among the kindred genera is in *Margarita arctica* Leach," etc. Monograph of Vitrinella, Amherst, Mass., Feb., 1850.

The above quotation shows the extended sense in which Mr. Adams intended his genus, *Vitrinella*, to be taken, and he afterwards added several species from Panama.

The original list included five new species from Jamaica, without mentioning any as a type, given in the following order : *V. hyalina*, *V. interrupta*, *V. megastoma*, *V. tincta* and *V. helicoidea*. None of these were figured until 1888, when figures of a species, named *V. helicoidea*, made from a specimen, were published in Tryon's Manual, x, pl. 34, figs. 40–41.

P. P. Carpenter, in 1855–57 (Mazatlan Mollusca, p. 236), mentioned the differences in the form of the many species referred to this genus by C. B. Adams and himself, but did not restrict it by naming any one of the above species as a type, and only stated that "*megastoma* is an *Ethalia*" and "that the indented species accord better with *Ethalia* and *Teinostoma*." He also stated "there are specimens of *V. tincta*, *V. interrupta*, *V. valvatoides*, *Teinostoma minuta*, and *Ethalia megastoma* in the Cumingian Collection." H. and A Adams, in 1858 (Gen. Rec. Moll.), were the next authors to define the genus, but gave a figure of *valvatoides* for an example ; this species, however, not being in the original list, cannot stand as the type.

I propose *V. helicoidea* as the type and restrict the genus to small, more or less hyaline, low-spired shells of few convex whorls, having a moderate-sized, deep umbilicus ; nearly circular, oblique aperture, with simple more or less continuous peritreme, modified on the body-whorl into a more or less conspicuous glaze, which may be absent in the young ; columellar margin often flattened in the adult, having the appearance of being thickened, and angulated at the lower, outer edge.

I have a group of such shells from shallow-water, off Cape Hat-

teras, N. C., represented by *V. helicoidea* C. B. Adams, *V. Tryoni* Bush, *V. diaphana* (d'Orb.), and *V. carinata* (d'Orb.)

As the family names Cyclostrematidæ and Adeorbidæ, if used at all, are applicable to other relations, I introduce Vitrinellidæ to distinguish this group and extend it to include all small, more or less hyaline, non-nacreous species, varying in form from those having a low, little raised spire and large umbilicus, like *Circulus*, to the higher spired, smaller umbilicated species, like *Lissospira*, and those with closed umbilicus, like *Tharsiella*. Taking the form of the umbilicus, the aperture, and peritreme, as the principal distinguishing characters of the several genera, such as :

Delphinoidea Brown, 1827, *Vitrinella* C. B. Adams, 1850, *Circulus* Jeffreys, 1865, *Ganesa* Jeffreys, 1883, *Granigyra* Dall, 1889, *Tharsiella* Bush, 1897, *Lissospira* Bush, 1897, *Leptogyra* Bush, 1897.

The correctness of such a grouping depends entirely on the future study of the opercula, animals, and odontophores.

List of species belonging to the marine fauna of eastern America which have been referred to *Vitrinella :*

Vintrinella hyalina C. B. Adams, *V. interrupta* C. B. Adams, *V. megastoma* C. B. Adams, *V. tincta* C. B. Adams, *V. helicoidea* C. B. Adams, *V. striata* (d'Orbigny) Tryon, *V. anomala* (d'Orbigny) Tryon, *V.* (*Episcynia ?*) *multicarinata* (Stimpson MSS.) Dall.

Cynisca H. and A. Ad., 1858. Type, *C. granulata* A. Ad. Philippines.

" Shell depressly turbinate ; umbilicus wide and deep, perspective, surrounded by a spiral callus ; whorls with transverse, granular ribs ; aperture circular ; inner lip straight, outer lip thickened, lirate within, continued posteriorly on the penultimate whorl beyond the inner lip." Gen. Rec. Moll., p. 406, 1858.

Type, *C. granulata*, not figured.

In Ann. and Mag. Nat. Hist., vol. viii, 1861, A. Adams, under the genus *Cynisca*, stated : " In our Gen. Rec. Moll., vol. i, p. 406, my brother and myself proposed a subgenus of *Cyclostrema* under the name *Cynisca*. This was founded on a shell in Mr. Cumings' collection, which I described as *Cyclostrema granulata* (P. Z. S., 1853). The great peculiarity consists in the aperture, which is something like that of *Stoastoma*, the inner lip being straight and the outer lip being continued posteriorly on the penultimate whorl beyond the inner lip."

He added two species, *Delphinula australis* Kiener, which has more recently been referred to the subgenus *Liotina* Munier-Chal-

mas, 1877, as its only living representative, and described the new species *Japonica*, which in 1863 he stated was the *Liotia pilula* Dunker, and transferred it to the genus *Collonia* Gray.

I very much doubt the near relation of this genus to *Cyclostrema*. The peculiarity of the aperture is much like that seen in *Leucorhynchia* Crosse, 1867, type, *L. Caledonica* Crosse (Journ. de Conch., xv, p. 320, pl. 11, f. 4), and *Craspedostoma* Lindström, 1884, type, *C. elegantulum* Lind. (Fischer's Manuel, p. 831, f. 588).

Mörchia A. Adams, 1860, *non* Albers,[1] M. Meyer, or Von Martens. Type, *M. obvoluta* A. Ad. St. of Korea, 26 fathoms.

"Shell obliquely ovate, widely umbilicate, depressed, convex from above, plane or flattened from beneath; whorls rapidly increasing, the last dilated, covering all the volutions nearly to the apex. Aperture oblong, oblique, subhorizontal, dilated or expanded below, angulated above; peritreme continuous, thickened (*incrassato*)."

Type, *M. obvoluta* A. Ad. Figured in Thes. Conch., copied by Tryon.

"Shell small, opaque, white, angulated at the periphery, ornamented with crowded incremental striæ; umbilicus wide, crenulated at the suture."

"This curious little genus most nearly resembles *Teinostoma*, but the base is not covered with a callus, and the mouth is not produced. The last whorl embraces the others, as it does in *Neritula* and *Cyclops*. Both *Mörchia* and *Teinostoma*, however, together with *Vitrinella*, are not nacreous," etc., etc. Ann. Mag. Nat. Hist., v, p. 301, 1860. P. Z. S., p. 74, 1863.

The affinities of this genus are very doubtful, but the thickened peritreme would prevent its being placed with the Vitrinellidæ.

Daronia A. Adams, 1861. Type, *D. spirula* A. Ad. Philippines.

Serpularia Römer, 1843 (? *Spira* Brown, 1838), H. and A. Adams, Gen. Rec. Moll., p. 406, 1858.

"Shell orbicular, discoidal, evolute; spire depressly concave; whorls rounded, disunited; aperture circular; peritreme continuous."

Type, *D. spirula* A. Ad. Figured P. Z. S., 1850, and Thes. Conch., copied by Tryon. The original figure differs considerably from those in Thes. Conch., as copied by Tryon.

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[1] *Mörchia* Albers, 1850 = *Macrocyclis* Beck, 1837, pro parte. *Mörchia* M. Meyer 1860 = *Burtinella* Mörch, 1861. (Fischer's Manuel, pp. 456 and 692.)

In 1861 (Ann. Mag. Nat. Hist., vol. viii, p. 244), A. Adams stated: "The very remarkable shell described by me as *Cyclostrema spirula* (P. Z. S., 1850) is neither a *Spira* nor a *Serpularia* and the name of the subgenus may therefore be changed to *Daronia*."

I have been unable to consult Sowerby's Thes. Conch., 1864. Fischer used *Daronia* as a section of *Cyclostrema*, but his conception of that genus was in its most extended sense.

Serpularia was used by Munster (1840) for a genus of annelids, and by Römer (1843) for a group of shells, some of which have been found to be annelid tubes. Fischer, however, retained it as a questionable genus (Manuel, pp. 716, 830), and gave *S. centrifuga* Römer, as an example.

Spira Brown, 1838.

"Shell smooth, nearly globular or semiovate; spire small in proportion to the size of the body, and depressed; aperture enveloping the body. 2d ed. Ill. Cat. Gt. Britain, p. 20.

This genus was proposed by Brown for a group of seven of Montagu's species of *Helix*, all of which, with the exception of *variegata*, he had included in his genus *Delphinoidea*, 1827. They are doubtless only larval shells.

Fischer recognized the genus in Journ. de Conch., pp. 45 and 51, 1877, but I find no mention of it in his Manuel, nor do I find that it has been recognized by other authors.

Tubiola A. Adams, 1863. Type, *T. cornuella* A. Ad. St. of Korea, 63 fathoms.

"Shell somewhat unrolled or loosely coiled; whorls simple, round, with concentric striæ; aperture somewhat circular, peritreme continuous, margin sharp, entire."

Type, *T. cornuella* A. Ad. Figured in Thes. Conch., copied by Tryon.

"Shell somewhat discoid, oblong-ovate, thin, yellow-brown, widely umbilicate, apex raised; whorls $3\frac{1}{2}$, rapidly enlarging, round, the last free at the peritreme; with conspicuous incremental striæ; aperture oblique, transversely ovate; peritreme continuous, sharp, entire, expanded." Ann. and Mag. Nat. Hist., v, p. 412, 1860.

The only change that is made in the description of the more adult specimen is in the color, which is given as "dirty white."

"In this species, which I described from a young individual as a *Skenea* in Ann. Mag. for 1860, the whorls are disunited, but the volutions are not rolled on the same plane as in *Daronia spirula*." P. Z. S., p. 74, 1863.

There seems to be considerable doubt in regard to *T. nivea*, the other species described by Adams under this genus. In P. Z. S., for 1850, he described under *Cyclostrema*, as (*Turbo*) *nivea* Chemnitz, a species in the Cumings collection, which he stated is the *Delphinula lævis* of Kiener; and in 1863, under *Tubiola* he described as (*Turbo*) *nivea* Chemn., a rare species which is not in the Cumings collection, nor in any other, and is not *D. lævis* Kiener, and "agrees exactly with the original description and figures of Chemnitz." The *nivea* of Adams is described as having "the last whorl large, dilated in front, round at the periphery bordering upon or spreading out at the peritreme; aperture oblique, sub-circular, angulated below," etc., etc.

As it is impossible for any one to settle such confusion without a careful study of the specimens, I use *cornuella* as the type of the genus.

Fischer used *Tubiola* as a section under *Cyclostrema*, but unfortunately cited *serpuloides* (Montagu) as an example, and did not mention either of the above species.

The relation of the genus to *Mörchia* or possibly to *Skenea* can only be definitely settled by the comparison of authentic types.

Circulus Jeffreys, 1865. Type, *C. Duminyi* Requien = *striatus* Wood = *striatus* Philippi. Sicily, The Crag, and Ireland.

Plate XXIII. fig. 11.

"Very small, circular, nearly flat-spired with exceedingly wide and open umbilicus."

"Operculum circular with about a dozen volutions which wind spirally and gradually and converge to the centre."

Type, *C. Duminyi* (R.) Jeffreys.

Described in B. C., iii, p. 315, and poorly figured v, pl. 62, f. 5.

In 1883 (P. Z. S., p. 94), Jeffreys redefined the genus as follows:

"Animal not known."

"Shell coin-shaped or forming a circular, compressed disk, slightly nacreous or pearly; mouth quadrangular with a continuous peristome; umbilicus very wide; operculum multispiral, as in other genera of Trochidæ."

Specimens of *Duminyi* from both Naples and France, in the U. S. National Museum, have been loaned me through the courtesy of Dr. Dall. The above statement of their being slightly nacreous or pearly is very misleading and quite erroneous. The interior is very

smooth and shining and not at all pearly as understood in *Margarita*, etc. The mouth cannot be said to be quadrangular; the peritreme is not continuous in the young, and even in the adult is modified on the body-whorl into a very thin glaze. The operculum is very difficult to describe, as the whorls are not clearly defined. It is circular, very thin, of a delicate horn-color, with central nucleus. Around the center are two or three evenly separated circles (whether spiral or not, I cannot determine), outside of these are irregularly disposed wrinkles, with an occasional, very faint, more definite circle. I encountered the same difficulty in studying the operculum of *trilix* (even when mounted in balsam). Five whorls represented by circles could be counted, but their spiral structure was impossible to trace.

Fischer placed *Circulus* as a subgenus of his *Solanderia*,[1] 1880, of the genus *Gibbula* Risso, 1826, among the Rhiphidoglossa.

The relation of this genus to *Vitrinella* seems very close, and the differences, although perfectly apparent when one has several species from both to study, are difficult to define. It therefore seems best to use *Circulus* simply as a section of *Vitrinella* for those species which, like *Duminyi*, have the more sinuate columellar margin and very wide umbilicus showing all the whorls. It should be redefined as follows :

Circulus Jeffreys, 1865 (sens. str.).

Shell small, circular, depressed, not nacreous, of few more or less convex whorls usually more or less grooved and carinated ; aperture nearly circular, oblique, somewhat angulated below ; peritreme simple, more or less continuous, in the adult modified on the body-whorl into a very thin glaze which is absent in the young ; umbilicus wide, the reverse of the spire ; operculum thin, light horn-color, with central nucleus, number of whorls doubtful (five or more ?)

Episcynia Mörch, 1875. Type, *E. inornata* (d'Orbigny). Island of St Thomas.

"Shell hyaline, the carina with a double series of cilia, apex simple, not inverted." Synopsis Molluscorum Marinorum Indiarum occidentalium, p. 155, mala. Blätter, xxii, 1875.

Type, *E. inornata* (d'Orbigny).

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[1] *Solanderia* Fischer, 1880 (*non* Duchassaing and Michelotti, 1846) = *Rossiteria* Brazier, 1895 (type, *Trochus nucleus* Philippi). Proc. Linn. Soc. N. S. Wales, ix, 2d series, p. 728, 1894–5.

"Shell orbicular, convex, conoid, smooth, shining, white, carinated; spire conic with obtuse apex, of five distinct, convex whorls; umbilicus small, smooth; aperture oval. Diam. 3^{mm}; alt. 2^{mm}."

Hist. L'île de Cuba, Moll., ii, p. 67; atlas, pl. xix, figs. 25–27, 1853.

Prof. Mörch constituted the above as a subgenus under *Architectonica* Bolten, 1798 = *Solarium* Lamarck, 1799.

Prof. Fischer placed it, with a mark of doubt, in the same relation; but Dr. Dall (Bull. M. C. Z., xviii, pp. 273, 392, 1889) suggested that it might prove to be more closely related to *Adeorbis* (i. e. *Circulus*) or to a *Vitrinella* (?) like *V. multicarinata*, which he described as having the epidermis produced into a fringe on the secondary carinæ, above and below the peripheral one. The hairy epidermis would exclude this species from *Vitrinella*, p. 105.

Trachysma G. O. Sars, 1878 (Jeffrey's MSS.) Type, *T. delicatum* (Philippi). Italian Tertiary and Lofoten Is., 200–300 fathoms.

"Shell globular, rather thin, similar to a *Cyclostrema* (i. e. *Lissospira*) but more delicate, aperture open or spreading out, peritreme simple, with a very thin, distinct edge."

Type, *T. delicatum* (Philippi) G. O. Sars.

"Shell thin, semipellucid, white, globular with short, little elevated spire, consisting of three and one-half convex whorls, the last large, evenly convex, the base not flattened. Suture deep. Aperture large, round-ovate with the outer-lip evenly arched and the columella slightly incurved. Umbilicus deep, not defined from the base (i. e. with rounded walls). Upper part scarcely shining, to the naked eye smooth, but seen under the microscope very finely sculptured, with numerous longitudinal and interrupted spiral lines. Diam. $1{\cdot}1^{mm}$; alt. 1^{mm}."

Var. *expansa* G. O. Sars.

"Shell more dilated, the last whorl wide and very large, the base slightly flattened, the aperture widely open and expanded in an unusual manner, the lip oblique and irregularly curved. Diam. basis $1{\cdot}4^{mm}$; alt. $1{\cdot}2^{mm}$." Moll. Reg. Arct. Norv., p. 211, pl. 22, figs. 17–18*d*, 1878.

Although Mr. Jeffreys seems to have proposed the name *Trachysma* for a species from Lofoten Is. which he identified as the *delicatum* of Philippi, I fail to find any reference to such a genus or species in any of his later reports on the "Porcupine Expedition." Therefore G. O. Sars should stand as the authority for the genus.

He placed it with the Solariidæ, but his figures (18*a–d*) of the

typical form would place the genus in close relation to *Lissospira* or possibly *Leptogyra*, although no epidermis is mentioned; but the form of the aperture of the variety *expansa* (figs. 17*a–b*) is very different and much closer to that of his *Adeorbis fragilis* (figs. 19*a–c*), the generic relation of which is very doubtful.

Fischer placed the genus with the Adeorbidæ with a mark of doubt, while Tryon (Manual, x, p. 13) placed it as a synonym of *Archytæa* de Costa, 1869, which is said by him to have the same type, *A. delicatum* of Philippi (p. 87). I have been unable to consult the Ann. Mus. Naples, iii, in which the latter genus is described. Fischer placed this with *Solarium* with a mark of doubt, but gave *A. catenulata* de Costa for an example.

Tharsiella[1] Bush, 1897. Type, *T. romettensis* (Seguenza). Pliocene. Calabria and Sicily. Mediterranean, Bay of Biscay, etc., in 108–1093 fathoms.

"Shell globular, solid and glossy; peristome circular and continuous, but attached to the pillar on that side: base closed by a pad or thick testaceous layer in the adult, perforated in the young: operculum chitinous or horny, and multispiral."

"This genus differs from *Cyclostrema* (i. e. *Lissospira*) in the peristome being, although continuous, not free or detached from the rest of the shell, and in the umbilicus being closed instead of open in the adult," etc., etc. P. Z. S., p. 92, pl. xix, fig. 7, March, 1883.

Fischer placed this as a subgenus under his *Cyclostrema*, but Mr. Dall (Bull. Mus. Comp. Zoöl., xviii, pp. 361–3, 1889) thought it might prove to be a synonym of, or at most, a feebly characterized section of *Ethalia;* but his conception of that genus is in its most extended sense. See p. 116. Moreover, Mr. Jeffreys may have had two forms under the name *romettensis*, for his figure 7 certainly more closely resembles a *Lissospira* than an *Ethalia*, so that I place the genus with the Vitrinellidæ until some knowledge of the animal and odontophore can definitely decide its position.

The specimen (No. 38244) from off Cape Hatteras, N. C., station 2115, in 843 fathoms, described by Professor Verrill (these Trans., vi, p. 201) as *Tharsis* sp., is unquestionably a small species of *Natica*. The aperture is broad-ovate, somewhat produced; the peritreme is modified on the body-whorl into a rather conspicuous glaze. and the columellar margin is thickened and reflected over the umbilical chink, with a slight median expansion.

[1] *Tharsis* Jeffreys, 1883, *non* Giebel, 1847 (Pisces); *nec Tharsus* Leconte, 1862 (Insecta.)

Ganesa Jeffreys, 1883. Type, *G. nitidiuscula* Jeffreys. Off the Hebrides. 570 fathoms.

"Shell shaped like a *Natica*, thin, peristome continuous, free and separate in the young, but united to the periphery in the adult, spire having an oblique axis; base perforated, not umbilicate; operculum horny, multispiral."

"Differs from *Tharsis* in the obliquity of the spire and perforation of the base at every stage of growth." P. Z. S., p. 94, March, 1883.

Two very distinct forms were described and figured under this genus, neither of which were mentioned as the type. *G. pruinosa*, in general appearance, shape of aperture, and peritreme, agrees closely with *Cyclostrema* (i. e. *Lissospira*) *affine*, and differs chiefly in having a peculiar granular surface. Several species having the same peculiarity have more recently been dredged by the U. S. F. C. at considerable depths in southern waters, for which group Mr. Dall constituted the section *Granigyra*.

Therefore as the other species, *G. nitidiuscula* Jeffreys, will stand for the type of the genus, it will be necessary to make some changes in its definition.

G. nitidiuscula Jeffreys.

"Shell differs from *G. pruinosa* in being exactly globular, opaque, and glossy; the sculpture consists of flexuous but slight and remote raised striæ in the (direction of the) lines of growth; the last or body-whorl is not so disproportionately large; the apex of the spire is depressed; the mouth is angulated both above and below, and the umbilical chink is channelled. L. 125, B. 125." P. Z. S., p. 94, pl. xix, figs. 9–9*a*, Mar., 1883.

Ganesa Jeffreys, 1883 (sens. restr.)

Shell resembling a *Lissospira* in general appearance, but differing in having the aperture modified by the body-whorl and angulated both above and below, and also in having the umbilical chink channeled and partly concealed by the columellar margin.

Operculum and animal unknown.

Fischer placed this genus as a subgenus of his *Cyclostrema*, but cited *G. pruinosa* for an example.

Until the odontophore is known, I consider it but a subgenus of *Lissospira*, for the reception of species which, like *Lissospira Dalli*, have the umbilical chink bordered along its outer margin by a raised rounded thread so that it appears channeled, and is nearly concealed by the more or less flattening and spreading out of the columellar margin of the peritreme. See also *Cirsonella* Angas, p. 120.

Granigyra Dall, 1889. Type, *G. limata* Dall. Off Cuba, 310 fathoms.

"Shell covered with small pustules or granules like those on Poromya or Plectodon."

"This singular little shell is a typical *Cyclostrema* (i. e. *Lissospira*[1]) in its conchological features, except for its granular surface. The latter recalls that of *Poromya*, but is finer and less regular." Bull. Mus. Comp. Zoöl., xviii, p. 395, 1889.

Specimens of *G. limata* Dall and *G. spinulosa* Bush in Professor Verrill's collection have a small umbilicus or perforation; the aperture nearly circular, with a slight sutural angle, and the peritreme simple, entire, and but slightly attached to the body-whorl, so that the section will come under the new genus *Lissospira*, until some knowledge of the operculum and animal can be obtained, which may give it generic distinction.

There is a group of small, white, solid, nearly smooth, porcellanous shells which have been referred to *Ethalia* (since 1855–7), *Teinostoma*, *Pseudorotella*, *Calceolina*, *Cirsonella*, and *Dillwynella*. They have several features in common, agreeing especially in having the umbilical region wholly, or in part, covered with a callous deposit. It therefore seems probable that they may, upon further examination, prove to be closely related to each other. Their family relations, however, will be difficult to determine, as the operculum and animal even of most of the type species are unknown. The solid porcellanous character of the shells together with the callosity covering the umbilicus would indicate closer affinity to the genus *Umbonium* Link, 1807 (type, *M. vestiarium* (Linné), sub-family Umboniinæ, H. and A. Adams), rather than to the thinner, more delicate, mostly semi-transparent species referred to the several genera belonging to the Vitrinellidæ.

Therefore, instead of placing the above genera chronologically with those already considered, I have, for convenience, grouped them as follows:

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[1] **Heliciella** Costa, 1861, *non Helicella* Ferussac, 1819 (1821?) *nec Helicelle* Lam., 1812.

I have been unable to consult the original description of this genus, and therefore do not know whether it bears any relation to *Lissospira* or not. Tryon (Manual, x, p. 96) made *Helicella* (*Heliciella* index) *mutabilis* Costa a synonym of *Cyclostrema Cutleriana* Clark; (ix, p. 296) he mentioned *Heliciella* as equal to *Megalomphalus* Brusina, 1871, in part, but did not quote either the description or type.

Ethalia A. Adams, 1853. Type, *E. Guamense* (Quoy and Gaimard). Is. of Guam. and Philippines.

"Shell orbicular, turbinately depressed; whorls smooth or transversely striated, convex, rounded at the periphery; umbilicus partly closed by a callous deposit." P. Z. S., p. 189, 1853.

This was constituted as a sub-genus of *Umbonium*, for two species of variously colored shells, *E. Guamense* (Q. and G.) and *E. striolatum* A. Ad. (described), closely resembling that genus but having the umbilicus only partially covered by a callous deposit. Neither was mentioned as a type species. H. and A. Adams, in 1858 (Gen. Rec. Moll., p. 409), added to the description "columellar lip ending anteriorly in an obtuse dilated callus," but cited the same two species as the only known examples.

P. P. Carpenter, in 1855–7 (Mazatlan Mollusca, p. 250), described five new species of small shells which he referred to *Ethalia* with some doubt; for, although they had "the general aspect of *Vitrinellæ* they agreed with *Globulus* in having callous bases," but differed in having the callus "generally not covering the umbilicus."

A. Adams, in 1861 (Ann. Mag. N. H., viii, p. 305), described three new species as belonging to the genus *Ethalia;* but the first one *E. atomaria* is described as a small, semi-transparent, white shell, with the umbilical region entirely covered by a callus; outer lip produced; which shows it to be quite different from either of the two original species and much nearer to *Teinostoma politum* A. Ad. or *Pseudorotella semistriata* (d'Orb.) Fischer.

These two instances will suffice to show the erroneous application of the genus. Unfortunately, this has been adopted, apparently without question, by more recent authors, so that a reconsideration of the subject is necessary before the right relations of the numerous species can be satisfactorily determined.

Mr. Pilsbry (Manual, xi, p. 457) called attention to the confusion into which the genus had been brought and gave *Ethalia Guamense* (Q. and G.) as the type.

List of species belonging to the marine fauna of eastern America which have been referred to *Ethalia:*

Ethalia diaphana (d'Orb.) Dall = *Vitrinella diaphana* (d'Orb.) Bush, *E. anomala* (d'Orb.) Dall = *Vitrinella anomala* (d'Orb.) Tryon, *E. semistriata* (d'Orb.) Poulsen = *Pseudorotella semistriata* (d'Orb.) Fischer, *E. multistriata* Verrill = *Vitrinella? multistriata* (Verrill) Bush, *E. reclusa* Dall, *E. suppressa* Dall, *E. solida* Dall, *E.* (*Dillwynella*) *modesta* Dall.

Teinostoma A. Adams, 1853. Type, *T. politum* A. Ad. Santa Elena, 8 fathoms.

"Shell orbicular, depressed, subspiral, polished, last whorl rounded at the periphery; umbilical region covered with a large flat callosity; the aperture transverse, rounded, greatly produced and elongated, ending anteriorly in a slightly canaliculated point; inner lip smooth, and callous, not emarginate or truncate anteriorly; outer lip thin, simple, not marginal or reflected. Animal? operculum?"

"Although but a single species has been found, I have made a genus of this singular shell, because I was unable fairly to refer it to any known form. It has resemblances to *Cyclops*, *Camitia*, and *Rotella* but agrees with neither." P. Z. S., p. 183, pl. x, figs. 1–3, 1853.

H. and A. Adams, in 1858 (Gen. Rec. Moll., p. 123) stated: "This curious little genus very much resembles at first sight *Camitia* of Gray, a genus of Trochidæ, from which, however, it is readily distinguished. Its true affinity is with *Neritula*, from which it is known by the absence of the notch at the fore part of the aperture, and by the very peculiar elongation of the mouth." *T. anomalum* C. B. Adams was added as a second known species; but p. 615 they stated that the "*anomalum* C. B. Adams should be *pusillum* C. B. Adams" (see page 119), and added three other species to the list. They also considered the relations of the genus to be nearer *Umboniium* as suggested by P. P. Carpenter, and transferred it to the subfamily Umboniinæ.

Megatyloma (type *T. wateleti* Desh.) was proposed by Cossmann as a section under *Teinostoma* (Cat. Coqu. Foss. Eocene, Paris, iii, p. 50, 1892).

P. P. Carpenter (Mazatlan Mollusca, p. 253) called attention to the fact that as the genus was "described from a single species, some of the characters before given may hereafter prove to be only specific."

Certainly if "greatly produced and elongated, ending anteriorly in a slightly canaliculated point," could be taken as a specific character and be omitted from the above description of the genus, it would be possible to rightly refer many more species to it.

Fischer associated *Teinostoma* with *Cyclostrema* in his family Cyclostrematidæ, and Tryon with *Vitrinella*.

List of species belonging to the marine fauna of eastern America which have been referred to *Teinostoma:*

Teinostoma diaphanum (d'Orb.) Tryon = *Vitrinella diaphana*

(d'Orb.) Bush, *T. carinatum* (d'Orb.) Tryon = *Vitrinella carinata* (d'Orb.) Bush, *T. pusilla* (Pfr.) Poulsen = *Pseudorotella pusilla* (Pfr.) Fischer, *T.* (*Pseudorotella*) *semistriata* (d'Orb.) Fischer, *T. cryptospira* (Verrill) Dall.

Fig. 1.

Fig. 2.

The *Rotella cryptospira* Verrill (these Trans., vi, p. 241, 1884) from off Cape Hatteras, N. C., in 142 fathoms, would seem to be a true *Teinostoma*, as suggested by Mr. Dall. Figs. 1, 2.

It is a small, solid, porcellanous, white shell with the umbilicus entirely covered with a rather thick, clearly defined, flat pad of callous deposit, distinctly separated from the columellar lip; edge of the peritreme simple, rounded, not sharp, owing to the thickness of the shell; but the aperture is not at all "produced and elongated."

Pseudorotella Fischer, 1857. Type, *P. semistriata* (d'Orbigny). West Indies.

"Animal? Operculum?

"Shell small, transparent, globular or flattened, whorls few, finely striated; umbilicus covered over with a brilliant transparent callosity; peritreme not continuous, right border curved, simple, acute." Jour. de Conch., vi, p. 52, 1857.

Type, *P. semistriata* (d'Orbigny).

"Shell orbicular, depressed, thin, transparent, white, above transversely (i. e. concentrically) striate, beneath polished; umbilical callus, shining; spire very short, obtuse, whorls four, slightly convex; aperture oval. Diameter $1{\cdot}5^{mm}$; height $\frac{2}{3}^{mm}$." Histoire L'ile de Cuba, Moll., ii, p. 61; atlas, pl. xviii, figs. 20–22, 1853.

Fischer (Manuel, p. 234) considered this a subgenus of *Teinostoma*.

List of species belonging to the marine fauna of eastern America which have been referred to *Pseudorotella:*

Pseudorotella semistriata (d'Orb.) Fischer, *P. pusilla* (Pfeiffer) Fischer = *diaphana* (d'Orb.) = *Vitrinella diaphana* (d'Orb.) Bush, *P. carinata* (d'Orb.) Fischer = *Vitrinella carinata* (d'Orb.) Bush, *P. anomala* (d'Orb.) Fischer = *Vitrinella anomala* (d'Orb.) Tryon, *P. striata* (d'Orb.) Fischer.

Pseudorotella minuscula sp. nov.

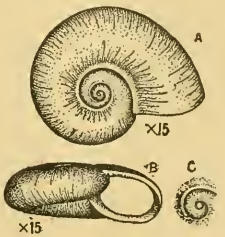
Figure 3, *a*, *b*, *c*.

A single, minute, dead shell from station 2283, off Cape Hatteras, N. C., in 14 fathoms, 1884, has the umbilical region entirely covered

by a thin, very lustrous glaze or layer of enamel, not in any sense a thickened pad, as in *Teinostoma*.

Shell thick, solid, porcellanous, slightly tinted with yellow along the suture and on the base ; flattened above and below, with the indented umbilical region covered with a thin lustrous glaze or layer of enamel. Surface smooth and very lustrous, marked only by irregular, microscopic, growth lines. Suture inconspicuous. Whorls about $2\frac{1}{2}$, coiled in the same plane, lapping well on to each other, rapidly enlarging, with a very small nuclear whorl and large body-whorl. Aperture very oblique, somewhat ovate; peritreme not continuous, modified into a thin, inconspicuous glaze on the body-whorl, elsewhere with rounded edge, with a slight callous deposit beneath the suture where the outer-lip extends obliquely well forward from the body-whorl, with little, if any, curvature and forms a slight sutural notch.

Fig. 3.



nucleus.

Greatest diameter, about $1{\cdot}5^{mm}$; height, about $\cdot5^{mm}$.

In form, this species approaches *Teinostoma cryptospira* (Verrill) Dall, but it is a much smaller shell, with the whorls quite differently coiled and with the umbilical callus represented by a thin glaze.

Calceolina A. Adams, 1863. Type, *C. pusilla* C. B. Adams. Jamaica.

"Shell like a *Neritina*, oblong, depressed, with small spire. Whorls rapidly increasing; umbilical region callus. Aperture semi-circular, interior not pearly with the inner lip concealed by a large, broad callus covering the umbilicus behind, with a simple, straight, front edge."

Type, *C. pusilla* C. B. Adams. Ann. Mag. N. H., xi, p. 267, 1863.

The type was described by C. B. Adams as a *Neritina*, which it very strongly resembles, so that I question its rightful relation to this group of shells, but H. and A. Adams, Fischer, and Tryon, all used the genus as a section under *Teinostoma*.[1]

[1] The genus *Discopsis* de Folin, 1869, (type, *D. omalos* de Folin, West Indies) (Fonde de la Mer, i, pp. 190, 205, pl. 23, f. 6, 1869) is also placed by Fischer, Tryon, and others as a sub-genus under *Teinostoma*. Judging from the description and figures as given by Tryon, it seems to me very distinct. The genus *Cochliolepis* Stimpson, 1859 (type, *C. parasiticus* St., Charleston, S. C.) (Proc. Boston Soc. Nat. Hist., vi, p. 308, with three cuts, 1857–1859) was placed by Mr. Dall next *Discopsis* (Bull. U. S. Nat. Mus., No. 37, p. 162, 1889), but he also suggested its possible relation to the genus *Vitrinella* (Bull. Mus. Comp. Zoöl., xviii, p. 360, 1889).

Cirsonella Angas, 1877. Type, *C. australis* Angas. New South Wales.

"Shell minute, globosely turbinate, smooth, narrowly umbilicated; aperture circular; peritreme continuous, slightly thickened."

Type, *C. australis* Angas.

"Shell globosely turbinate, narrowly umbilicate, semi-opaque, smooth, shining, white; whorls 4, convex; the last large, rounded at the periphery; aperture circular, peritreme continuous, slightly thickened on the columellar margin. Alt. 1 line, breadth, 1 line." P. Z. S., p. 38, pl. v, f. 16, 1877.

Mr. Angas placed this genus provisionally among the Trochidæ. The "slightly thickened" as given for the peritreme in the generic description is rather misleading, as it is definitely stated in the description of the type to be "on the columellar margin."

At my request Mr. Smith has very courteously examined the type which is in the British Museum. The following is an extract from his letter under date of May 7th:

"We have the type of Angas' *Cirsonella australis*, and it is placed at present in the neighborhood of *Ethalia*.

"It is a very minute, but solid, porcellanous shell, narrowly umbilicate, smooth, with a circular mouth, continuous *double* peristome, the inner edge looking as if it might support a shelly operculum as in *Bithynia*. The upper figure in P. Z. S., 1877, pl. v, f. 16, is a good representation of the shell generally; the figure of the underside is out of drawing and does not give the idea of a round aperture and continuous lip. From its texture and general aspect I think it may be left in its present location. Some of the small *Ethalias* approximate rather closely to it, but their peristomes are not quite so markedly continuous," etc.

The open umbilicus would, however, exclude it from *Ethalia* in its restricted sense, so that the proper relations of the genus are still doubtful. In outline, form of aperture, continuous peritreme, and small umbilicus, it strongly resembles *Lissospira* Bush, (p. 129,) but with the exception of *L.* (*Ganesa*) *rarinota* Bush, the species of that genus have shells of delicate texture and not at all solid and porcellanous. Its affinities may possibly prove to be such that the subgenus *Ganesa* Jeffreys 1883 (p. 114) would become synonymous.

Dillwynella Dall, 1889. Type, *D. modesta* Dall. Off St. Lucia, 226 fathoms.

"Shell resembling *Diloma* in form, but minute, depressed, porcellanous, with a thin, horny operculum of comparatively few whorls;

imperforate, but with a depression bounded by a riblet in the umbilical rib (region ?) outside of the columella; whorls few with a thin fugacious epidermis; outer lip thin ; pillow without teeth, projection, or folds, passing smoothly into the anterior margin."

Type, *D. modesta* Dall.

"This little shell will not fit into any of the groups defined in the text-books, resembling more than any other group the Rotellidæ, from which it differs in wanting the sutural fasciole, the nacreous layer, and the basal callus, as well as in possessing an epidermis. It is remarkably solid for its size, and of a peculiar opaque whiteness, like *Mamma* among the Naticidæ." Bull. Mus. Comp. Zoöl., xviii, p. 362, pl. xxi, figs. 3, 3*a*, 1889.

This was proposed as a subgenus of *Ethalia*, but it is questionable if the species referred to that genus by Mr. Dall could rightfully belong to it, when taken in its most restricted sense. In some features it comes near the subgenus *Ganesa* Jeffreys. See pp. 114, 116.

The following genera have been classed with the Cyclostrematidæ by Fischer and Tryon. In several features, their types seem much nearer the genus *Liotia* Gray and related genera, than any of those of the preceding group.

Microtheca A. Adams, 1863. Type, *M. crenellifera* A. Ad. Japan.

Globosely turbinate; peritreme continuous; umbilicus wide, crenulated. Operculum unknown. Ann. Mag. N. H., xi, p. 265, 1863. Figured in Thes. Conch., copied by Tryon.

Haplocochlias P. P. Carpenter, 1864. Type, *H. cyclophoreus* Carpenter. Lower California.

Similar to a *Collonia* but not margaritaceus, with a continuous thickened peritreme having an exterior varix; young umbilicate, adult lacunate. Animal and operculum unknown. Ann. Mag. N. H., xiii, p. 476, 1864.

Leucorhynchia Crosse, 1867. Type, *L. Caledonica* Crosse. New Caledonia.

In the peculiar callous rostrum prolonged past the umbilical region, this genus approximates to *Craspedostoma* Lindström. Journ. de Conch., xv, p. 319, pl. 11, f. 4, 1867.

VITRINELLIDÆ.

Cyclostrematidæ auth., in part and **Adeorbidæ** Dall, in part.

Vitrinella C. B. Adams, 1850. See page 105.

Type, **Vitrinella helicoidea** C. B. Adams.

Vitrinella helicoidea C. B. Adams, Monograph of Vitrinella, p. 9, 1850. *non* Tryon, Manual, x, pl. 34, figs. 40, 41, 1888.

Plate XXIII. figs. 9, 9*a*.

"Discoidal: white, opaque and translucent in transverse alternating lines: with a single impressed spiral line near the summit of the whorls, and very fine irregular transverse striæ; apex very obtuse; spire slightly and convexly elevated; whorls four, moderately convex, rapidly increasing with a lightly impressed suture; last whorl regularly rounded, a little compressed beneath. Aperture not modified by the last whorl; labium with a rather thick deposit; umbilicus large and deep, with a spiral carina, exhibiting all the whorls. Mean divergence about 150°; length of spire ·01 inch; total length ·03 inch; greatest breadth ·075 inch; least breadth ·06 inch."

A specimen from station 2280, off Cape Hatteras, N. C., in 16 fathoms, agrees so closely with Adams' description that I have ventured to figure it as an example of this, the type species of *Vitrinella*.

It is a small, semi-transparent, smooth, shining shell of about three and one-half convex whorls, forming a very low spire with obtuse apex and large body-whorl. Suture inconspicuous with an internal spiral line just below it showing through the shell. Umbilicus moderate, deep, showing all the whorls, with straight walls, distinctly angulated and defined on its outer margin by a rather small, rounded thread. Aperture oblique, nearly circular. Peritreme simple with a thin sharp edge, becoming thickened and rounded along the columellar margin and modified on the body-whorl into an inconspicuous, irregular, very thin glaze.

In a basal view the aperture is decidedly angulated below, the lip curving forward from the body-whorl, then backward and abruptly inward to join the sinuous pillar-lip.

Under the microscope the surface is marked by very delicate sinuous raised lines in the direction of the lines of growth.

Greatest width, about $2{\cdot}3^{mm}$; height about 1^{mm}.

The higher spire and angulated and carinated umbilicus distinguish this species from *V. helicoidea* as figured by Tryon.

Vitrinella Tryoni sp. nov.

? *Vitrinella helicoidea* Tryon, Manual, x, pl. 34, figs. 40, 41, 1888.

Plate XXII. figs. 11, 11*a*.

A specimen from station 2278, off Cape Hatteras, N. C., in 16 fathoms, very closely resembles the figures in Tryon's Manual given as *V. helicoidea*.

It is a smaller, more transparent shell than the preceding, consisting of about three flatly convex whorls, which lap well on to each other, forming a very much flattened spire, and large body-whorl. Suture inconspicuous, with an internal spiral line considerably below it showing through the shell and indicating the width of the lapping on of the whorls. Umbilicus moderate, deep, showing all the whorls, with rounded walls, not defined by a carina as in *V. helicoidea*. Unfortunately the lip is broken, but the general form of the aperture is as in the preceding species, but with the columellar margin less thickened.

Greatest width, about 2^{mm}; height, about $\cdot 8^{mm}$.

Vitrinella diaphana (d'Orbigny).

Rotella diaphana d'Orbigny, Histoire L'Ile de Cuba, Moll., ii, p. 62; atlas, pl. xviii, figs. 23–25, 1853.

A specimen from station 2113, off Cape Hatteras, N. C., in 15 fathoms, very closely resembles the figures given by d'Orbigny as *Rotella diaphana*.

It is a minute, smooth, shining, opaque white shell consisting of about three well-rounded whorls, forming a well-raised spire with minute nuclear whorl and large body-whorl. Suture distinct. Umbilicus rather small, deep, with rounded walls, showing only a part of the whorls. Aperture as in *V. helicoidea*, but with the columellar lip not only thickened but flattened and spreading slightly over the umbilical region. Surface marked only by delicate microscopic lines of growth. Greatest width, about $1 \cdot 2^{mm}$; height, about $\cdot 8^{mm}$.

"Umbilical callus very minute," as given by d'Orbigny for this species as well as for *carinata*, has doubtless led to their being referred to *Pseudorotella*,[1] *Teinostoma* and *Ethalia*. The thickened

[1] *Pseudorotella* Fischer, Journ. de Conch., vi, p. 173, 1857 = *P. pusilla* (Pfieffer); *Teinostoma* Tryon, Manual, x, p. 104, 1888; *Ethalia* Dall, Bull. M. C. Z, xviii, p. 361, 1889. This species seems to have been referred also to *Cyclostrema* by Poulsen.

and flattened columellar margin corresponds to this, but there is not the slightest indication of a callus pad found in species of any of those genera. My specimen is somewhat worn, so that it is not at all transparent.

Vitrinella carinata (d'Orbigny).

Rotella carinata d'Orbigny, op. cit., p. 62 ; atlas, pl. xviii, figs. 26–28.

I have identified two specimens from station 2278, off Cape Hatteras, N. C., in 16 fathoms, as the *carinata* of d'Orbigny.

They are minute, semi-transparent, smooth, shining shells, similar in form to the preceding, but having on the body-whorl a distinct peripheral thread or carina which in some positions appears double. The surface under the microscope is marked by delicate lines in the direction of the lines of growth, and on the base by a few inconspicuous, raised, revolving lines, more distinct in one specimen than in the other. One of the specimens also appears to have an indistinctly flattened sutural area. Umbilicus, aperture, and columellar margin as in *V. diaphana*.

Greatest width, about $1{\cdot}2^{mm}$; height, about $\cdot 8^{mm}$.

Vitrinella ? multistriata (Verrill).

Ethalia multistriata Verrill, these Trans., vi, p. 242, 1884; Expl. Albatross, Report U. S. Com. Fish and Fisheries for 1883, p. 568, 1885. Dall, Bull. Mus. Comp. Zoöl., xviii, p. 361, 1889; Bull. U. S. Nat. Mus., No. 37, p. 160, 1889.

Plate XXII. fig. 7. Plate XXIII. figs. 4 and 14.

The specimens (No. 35733) from station 2109, off Cape Hatteras, N. C., in 142 fathoms, which were described by Professor Verrill as belonging to *Ethalia*, seem much nearer *Vitrinella*.

The young specimens are semi-transparent and shining, like *V. helicoidea*, *V. Tryoni*, etc., but the more mature ones are somewhat weather-worn and appear quite opaque but have considerable luster. The umbilicus is of moderate size, deep, showing part of the whorls, with the walls somewhat flattened. The aperture is similar in form to that of *V. helicoidea*, but in the adult the columellar margin is considerably thickened and flattened so that its outer margin is decidedly angulated below, where it joins the outer lip. There is, however, no callus pad covering the umbilical region.

Rotella anomala d'Orbigny (Hist. L'Ile de Cuba, ii, p. 64 ; atlas,

pl. xviii, figs. 32–34, 1853), should undoubtedly be referred to *Vitrinella* rather than to *Ethalia* as given by Mr. Dall (Bull. M. C. Z., xviii, p. 361, 1889).

Section **Circulus** Jeffreys, 1865. See page 110.

Adeorbis Wood, 1842, in part.

Type, **Circulus striatus** (Philippi) Pilsbry.

Adeorbis striatus Wood, Ann. Mag. Nat. Hist., ix, p. 530, pl. v, figs. 5–6, 1842; Mon. Crag. Moll., p. 137, pl. xv, fig. 7, 1848 = *Valvata? striata* Philippi (teste Wood).

Circulus Duminyi Jeffreys, B. C., iii, p. 315, 1865; v, p. 203, pl. lxii, f. 5, 1869 = *Solarium Philippii* Cantraine (teste Jeffreys).

Circulus striatus Pilsbry, Tryon's Manual, xi, p. 274, pl. 66, figs. 12, 13, 1889. (A very complete synonymy is given.)

Plate XXIII. fig. 11.

Mr. Dall has very kindly loaned me specimens of *Duminyi* from both Naples and the coast of France, in the U. S. National Museum.

They resemble the smaller species, the *liratus* of our coast, in having the upper part of the whorls covered with raised spiral threads separated by grooves, but the grooves are less deeply cut, making the alternating threads less elevated. The whorls are less swollen or convex, the suture shallower, the nuclear whorl, although of about the same size, is less elevated, causing the shell to appear lower and flatter, with a flatter base, a feature which increases with age.

The sculpture on the series of specimens from the coast of France is even less conspicuous than that on the single larger specimen from Naples.

Circulus liratus (Verrill).

Omalaxis (?) *lirata* Verrill, these Trans., v, p. 529, 1882.

Skenea lirata Verrill, op. cit., vi, p. 452, 1885. Bush, op. cit., vi, p. 464, 1885.

Adeorbis supranitidus, var. *Orbignyi* Dall, Bull. Mus. Comp. Zoöl., xviii, p. 278, 1889; Bull. U. S. Nat. Mus., No. 37, p. 150, 1889, in part.

Skenea lirata Bush, Bull. Mus. Comp. Zoöl., xxiii, p. 240, pl. i, figs. 11, 12, 1893.

Plate XXIII. figs. 7, 12–12*b*.

Found in considerable numbers off Cape Hatteras, N. C., in 8–43 fathoms, 1883–1884.

This species is considered by Mr. Dall to be the same as Fischer's *A. Orbignyi* from the West Indies. That, however, is a very minute species (diam. $1\frac{1}{2}^{mm}$; height 1^{mm}), ornamented, "with 12–15 elevate, acute, equidistant, concentric costæ," while the larger species, *liratus* (diam. $2\frac{1}{2}^{mm}$; height, about 1^{mm}), has but 9 or 10 cinguli or liræ.

Circulus Smithi Bush.

Cyclostrema tricarinatus Smith, P. Z. S., London, p. 737, pl. 75, fig. 26, 1871.

In studying the various figures published in Tryon's Manual I was impressed with the strong resemblance of the African species, *Cyclostrema tricarinatus* Smith, to the Crag species of *Adeorbis* Wood, esp. *tricarinatus*. I referred the matter to Mr. Smith, who writes me that upon comparing his species with those of Wood, he finds that there is unquestionably no generic distinction. He also states that his figures are accurate representations of the only specimen which he had of his species. As the specific name *tricarinatus* is preoccupied by Wood, I propose the name *Smithi* for this African shell. It differs from any of those on our coast which belong to *Circulus*, in having the entire surface covered by conspicuous revolving threads and grooves, in addition to three prominent carinæ.

Circulus Dalli sp. nov.

Plate XXIII. figs. 3, 3*a* and 6.

A single dead specimen, found among foraminifera, at station 2655, N. lat. 27° 22′, W. long. 78° 07′ 30″, in 338 fathoms, 1886.

This deep-water species is of more delicate texture and more transparent than the more northern shallow-water species of similar form. It is ornamented on the body-whorl with two rather inconspicuous carinæ, one defining the base and the other on the periphery; above this the surface is cut by about seven delicate, unequal, microscopic shallow grooves or striæ, the two uppermost being the most distinct; above these the surface is smooth and appears somewhat flattened; there are also a few less distinct striæ below the periphery and in the umbilical region.

Greatest width, about 3^{mm}; height, about $1{\cdot}4^{mm}$.

A smaller dead specimen (No. 44983) from station 2307, off Cape Hatteras, N. C., in 43 fathoms, agrees well with this species. It has however, in addition to the typical sculpture, a few smaller striæ just below the suture, and the grooves and alternating raised lines appear more distinct, the specimen being very much worn and twice injured and repaired by the animal.

This larger species, in its inconspicuous sculpture, seems to be a connecting link between the distinctly grooved ones and the carinated ones, so that we have a series of gradations in sculpture from the smooth variety of *supranitidus* through *supranitidus* (typical), *trilix*, *Dalli*, *Smithi*, *striatus*, up to the strongly grooved *liratus*.

Circulus trilix Bush.

Skenea trilix Bush, Expl. Albatross, Report U. S. Com. Fish and Fisheries for 1883, p. 584, 1885.

Non Homalogyra densicosta Tryon, Manual, ix, p. 399, pl. 61, figs. 10–11, 1887.

Adeorbis supranitidus Dall, Bull. Mus. Comp. Zoöl., xviii, p. 278, 1889; Bull. U. S. Nat. Mus., No. 37, p. 150, pl. xli, figs. 7, 7*a*, 1889, in part.

Plate XXII. figs. 6, 10, 10*a* and 12, *a–g*. Plate XXIII. figs. 10 and 15.

The most common species of this genus off Cape Hatteras, N. C., in 7–17 fathoms, 1883–1884.

The operculum of *trilix* is thin, horny, circular, of about five whorls with central nucleus. The animal matter, the shell having been removed with nitric acid, is too much dried to dissect but shows stout tentacles, prominent eyes situated at their bases, and a rather broad, bilobed snout (fig. 6). The radula, although extremely minute, measuring about ·3^{mm} in length and ·1^{mm} in width, reveals interesting characters and shows that this species unquestionably belongs to the Rhiphidoglossa. The radula (fig. 12) consists of between 50 and 60 rows of teeth; in each row there is a comparatively wide central tooth (fig. *d*) having a base with convex sides and bearing a long, finely serrated, strongly pointed hook; on either side a narrow, long, lateral tooth (fig. *e*) with a serrated hook; and beyond twenty or more delicately pointed, sickle-shaped, marginal ones (figs. *f*, *g*). These were revealed only when exceedingly high power objective and ocular, of a magnifying power of about 1000 diameters, were used, and even then only the higher lines could be seen; when using a lower power of about 500 diameters, only ten of the marginal hooks could be counted. See p. 128.

Circulus supranitidus (Wood) Jeffreys.

Adeorbis supranitidus Wood, Ann. Mag. Nat. Hist., ix, p. 530, 1842; Crag Mollusca, p. 137, pl. xv, figs. 5. *a–b*, London, 1848.

Circulus Duminyi Requien, var. *supranitidus* Jeffreys, B. C., iii, p. 315, 1865.

Adeorbis supranitidus Jeffreys, P. Z. S., London, p. 42, 1885.

Non Omalaxis supranitida G. O. Sars, Moll. Reg. Arct. Norv., p. 214, pl. 22, figs. 20 *a–b*, 1878=(O. (?) *Sarsi* sp. nov.)

Non Adeorbis supranitidus Dall, Bull. Mus. Comp. Zoöl., xviii, p. 278, 1889; Bull. U. S. Nat. Mus., No. 37, p. 150, pl. xli, figs. 7, 7*a*, 1889.

Plate XXIII. figs. 1 and 2.

Through the courtesy of Mr. Dall, I have been able to study two authentic specimens of *supranitidus* from the Crag, in the U. S. National Museum.

They are about half the size of a full-grown *trilix* and differ from specimens of that species of the same size, in lacking the distinct tricarination of the whorls, in having the whorls more convex and more regularly coiled, so that the body-whorl is not so abruptly enlarged, in having the spire relatively larger, and in the striation of the umbilicus. Both specimens of *supranitidus* have three conspicuous revolving threads separated by deep grooves in the umbilicus; one has a very prominent basal carina, the other has it but partially developed; in this specimen the whorls are perfectly smooth, while in the former the two faint upper carinæ commence just back of the aperture; neither show any trace of the microscopic striations found in *trilix*. In the many specimens of the latter which I have, there seems to be no variation in the size of the small nucleus, the relatively much smaller spire and abruptly enlarged body-whorl (a peculiarity which becomes more marked as the shell increases) and in the strong tricarination of the whorls, even in very small specimens. They differ only in the number and prominence of the threads in the umbilical region, and in the distinctness of the microscopic striations on the upper part of the whorls. The constancy of these characters ought to prove that the two species are quite distinct.

The four species, besides *subcarinatus* (Montagu), included in *Adeorbis* by Wood present two quite distinct forms; *pulchralis*, which bears a strong resemblance to a *Margarita*, and *supranitidus*, *tricarinatus* and *striatus*, which are quite different. Of these, *supranitidus* has caused the most confusion in synonymy, as no two writers seem to agree as to what it really is. As mentioned above, Mr. Jeffreys identified it as a fossil variety of *Trochus Duminyi* Requien, but in vol. v, B. C., 1869, he mentioned that that species should fall into the synonymy of *Solarium Philippii* Cantraine.

In 1878, Prof. G. O. Sars described and figured, as *supranitidus* Wood, a very minute Norwegian shell,[1] referring it to the genus *Omalaxis*. He stated that the spire is plane, not elevated; suture profoundly impressed, etc., etc. At the same time he defined the genus *Adeorbis* Wood, and described and figured a species very different in form from *subcarinatus* (Montagu), but closely resembling *pulchralis* Wood, with which Mr. Jeffreys compares it (Proc. Zoöl. Soc., London, p. 41, Jan., 1885). Prof. Sars places both genera in the family Solariidæ at the end of the Gymnoglossa.

[1] For this very distinct species, which does not seem to be very closely related generically to *Circulus*, I propose the name *Sarsi*, but very much doubt its near relation even to *Omalaxis*.

Mr. Jeffreys in 1875 changed his mind in regard to *supranitidus*[1] Wood, as the "Lightning and Porcupine Expedition," obtained specimens which he mentioned as "agreeing with the Crag specimens in every respect (especially in being tricarinated) except in being spirally and rather strongly striated," and added *A. tricarinatus* Wood as another variety. He further mentioned that "the operculum is not known, and it is therefore questionable whether the present species belongs to *Adeorbis* or *Homalaxis*." He however referred it to *Adeorbis*, but did not mention his genus *Circulus*.

Lissospira gen. nov.

Cyclostrema auth. in part.

This genus is proposed for a group of deep-water species which have been erroneously referred to *Cyclostrema*. They are small, thin, of rather delicate texture, opaque white, slightly lustrous, of few convex whorls forming an elevated spire, with relatively large, prominent nuclear whorl and large body-whorl. Suture deep, Umbilicus small, deep, not showing any whorls. Aperture somewhat oblique, circular with a slight sutural angle, not modified by the body-whorl to which the simple, continuous peritreme is but slightly attached, often having an indistinct thread just within the inner lip, fading out above and below, so that it extends but about half way round the aperture ; it is much nearer the edge along the columellar margin than at the ends and is evidently to prevent the thin operculum being drawn in too far. The operculum (fig. 4) is circular, thin, of a delicate horn-color, with central nucleus, of about seven whorls, defined by a distinct spiral thread ; often showing delicate, microscopic transverse growth lines. The radula consists of numerous rows of delicate teeth ; each row having one broad central, or median tooth, with a broad, blunt, delicately serrate, curved tip and on either side four more slender lateral teeth also with blunt, curved, delicately serrate tips, beyond which is a series of numerous, between 30 and 50, long, very slender, somewhat sickle-shaped hooks sometimes with delicately serrate tips. (G. O. Sars, Moll. Reg. Arct. Norv., tab. iii. f. 6 *b.* and *L. diaphana.*)

[1] The locality (New England, Verrill) given by Mr. Jeffreys, I have been unable to verify, as I find no such species on record or mention of it in any of Professor Verrill's papers.

Type, **Lissospira proxima** (Tryon).

Cyclostrema rugulosum Verrill, these Trans., v, p. 533, 1882, *non* G. O. Sars, 1878.
Cyclostrema affine Verrill, op. cit. vi, p. 199, pl. xxxii, fig. 15, 1884, *non* Jeffreys, 1883.
Cyclostrema sp. Verrill, Expl. Albatross, Report U. S. Com. Fish and Fisheries for 1883, p. 569, 1885.
Cyclostrema proxima Tryon, Manual of Conchology, x, p. 98, pl. 33, fig 4, 1888.
Cyclostrema trochoides Dall, Bull. Mus. Comp. Zoöl., xviii, p. 393, 1889; Bull. U. S. Nat. Mus., No. 37, p. 166, 1889.

Figure 4. PLATE XXII. fig. 3.

A comparatively few specimens were obtained by the U. S. F. C. at about twelve stations between N. lat. 41° 53′, W. long. 65° 35′ and N. lat. 35° 49′ 30″, W. long. 74° 34′ 45″, in 365 to 858 fathoms. A young specimen (No. 78460) from near stations 2692–6, N. lat. 46°+, W. long. 44°+, in 73–105 fathoms, was also identified as this species.

Fig. 4.

The operculum (fig. 4) is thin, of a delicate horn-color, slightly concave in front. The radula apparently had the same number of teeth in each row as in that of *L. diaphana* and *L. basistriata*,[1] but was unfortunately lost before the form of the median tooth could be satisfactorily determined.

Mr. Jeffreys seems to have had a very confused idea as to the exact form he intended to stand as the type of his species *trochoides*. A specimen which he identified for Dr. Friele as *trochoide* (published by the latter in 1875, not described) proved to be the *lævigatum* G. O. Sars, 1878 (teste Friele and Sars). Specimens identified as *trochoide* for Professor Sars, described and figured by him in 1878, must stand for the species, especially as Mr. Jeffreys himself never published a description or figure of it; Sars' species,

[1] There seems also to be some question in regard to the true *Cyclostrema basistriatum* Jeffreys, 1877, *non* Brugnone. In Ann. Mag. N. H., p. 234, 1877, under this species Mr. Jeffreys described three differently sculptured forms: *a*, "spiral striæ on base encircling the umbilicus"; *b*, "a single ridge-like stria at the top so as to give an angulated appearance to the summit"; *c*, "umbilicus surrounded by a strong keel-like stria"; while in P. Z. S., p. 90, 1883, he added the fourth, *d*, "striated throughout," and "*C. profundum* Friele is this form" (p. 141.) In 1886 Dr. Friele very decidedly stated that his species was not the *basistriatum* of Jeffreys. G. O. Sars described and figured the form having striæ on the base only and this ought to stand for the true or typical form and is undoubtedly a *Lissospira*. The *basistriatum* of Brugnone was said by Jeffreys to have been changed to *curvistriatum* Brugnone.

however, has been found to be a variety of Friele's *Petterseni* (1877) (teste Friele and Sars). In P. Z. S., p. 91, 1883, Mr. Jeffreys mentioned "The umbilicus is sometimes encircled by one or more strong spiral striæ," which leads me to think that he had still other forms erroneously referred to the species, more especially as Mr. Dall (op. cit., p. 393) states that "A careful comparison of types leaves no doubt as to the identity of these two forms" (*affine* V. and *trochoides* J.); but the figures given by both Friele and Sars are very unlike *affine* V. *Petterseni* is described as solid, perfectly smooth, white, with no umbilicus proper, but a more or less distinct umbilical fissure, and the figures show the form of the aperture and peritreme to be very similar to that figured by Jeffreys for the type of *Tharsis*=*Tharsiella*, as do also those given by Sars.

As the specific name *affine* was used in 1883 by Jeffreys for another species of *Cyclostrema* which now would be referred to *Lissospira*, the name *proxima*, given by Tryon in 1888, is adopted for Professor Verrill's species.

Lissospira diaphana (Verrill).

Cyclostrema diaphanum Verrill, these Trans., vi, p. 199, pl. xxxii, fig. 16, 1884; Expl. Albatross, Report U. S. Com. Fish and Fisheries for 1883, p. 569, 1885. Tryon, Manual of Conchology, x, p. 91, pl. 31, fig. 47, 1888. Dall, Bull. Mus. Comp. Zoöl., xviii, p. 393, 1889; Bull. U. S. Nat. Mus., No. 37, p. 166, 1889; Proc. U. S. Nat. Mus., xii, p. 355, 1889.

Plate XXII. fig. 2.

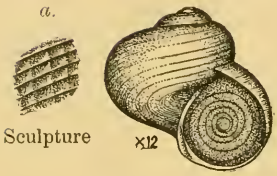
Two specimens (No. 38409), station 2084, off Martha's Vineyard, in 1290 fathoms, 1883, south to Brazil, in 281–1019 fathoms (Dall). The locality, station 2004, as given by Professor Verrill was a typographical error.

The operculum is similar to that of the preceding species and *basistriatum* as figured by Sars. The radula, however, shows interesting, though slight, differences from that of the latter. The median tooth being not broadly elliptical, but narrower above than below, the sides at first straight but curving strongly outward below, with a broad, blunt, delicately serrate, curved tip; on either side are four narrow, curved, lateral teeth, also with blunt delicately serrate hooked tips; beyond these are numerous, between 30 and 40, very fine, hair-like, delicately hooked marginal teeth; no serrations were found on these.

Lissospira striata sp. nov.

Figures 5, *a*.

Fig. 5.



One live specimen, station 2213, off Martha's Vineyard, in 384 fathoms, 1884.

Shell consisting of about three convex whorls forming a comparatively low, somewhat depressed spire. The entire surface below the relatively large, little raised, smooth nuclear whorl, is covered with raised, rounded, well-separated, revolving microscopic threads, most distinct on the base. Umbilicus small, scarcely more than a chink. Aperture and operculum typical.

Greatest width, about 2^{mm}; height, about $1{\cdot}5^{mm}$.

This species, in general form and sculpture, resembles *Cyclostrema* (=*Lissospira*) *Willei* Friele (Den. Nor. Nord.-Expd. 1876–78, xvi, Moll. ii, p. 34, pl. xi, fig 19, 1886), but that is a much smaller species with larger umbilicus.

Lissospira cingulata (Verrill).

Cyclostrema cingulatum Verrill, these Trans., vi, p. 198, pl. xxxii, fig. 14, 1884 (*non* Philippi *nec* Dunker); Expl. Albatross, Report U. S. Com. Fish and Fisheries for 1883, p. 569, 1885.

Cyclostrema Verrilli Tryon, Manual of Conchology, x, p. 90, pl. 31, fig 46, 1888.

Cyclostrema cingulatum Dall, Bull. U. S. Nat. Mus., No. 37, p. 166, 1889.

One specimen (No. 38100), station 2048, off Martha's Vineyard, in 547 fathoms, 1883.

As this species was erroneously referred to *Cyclostrema*, I do not adopt Tryon's specific name *Verrilli* for it.

Lissospira (?) convexa sp. nov.

A much mutilated, live specimen, station 2233 off Delaware Bay, in 630 fathoms, 1884.

Shell very fragile, consisting of four regularly increasing, very convex whorls, forming a high spire with abnormally relatively large, prominent, somewhat twisted, nuclear whorl. Suture very deep, umbilicus round, of good size, deep, with rounded walls. Aperture somewhat circular but modified by the body-whorl, to which the simple, continuous peritreme is attached for a considerable distance; columellar margin very straight, angulated at its

junction with the strongly curved outer-lip and reflected along the umbilical region, but not thickened. Surface appears smooth but under the microscope it is covered, except the nucleus, with delicate, much separated, spiral threads which extend up into the umbilicus. The animal is drawn so far into the shell that the operculum, if present, cannot be seen.

Greatest width, about 1.5^{mm}; height, the same.

Although at first sight this species strongly resembles a *Lissospira*, in the large size of its nucleus, regularly increasing whorls, and form of its aperture it approximates to *Rissoa* (*Setia*) *triangularis* Watson (Report Voy. Challenger, Zoöl. Scaphopoda and Gasteropoda, xv, p. 611, pl. xlvi, fig. 2, 1885), but is much smaller with more swollen whorls.

Subgenus **Ganesa** Jeffreys, 1865. See page 114.

Lissospira (Ganesa) Dalli (Verrill).

Cyclostrema trochoides Verrill, Notice of Recent Add. to Mar. Invert., Part II, Proc. U. S. Nat. Mus., iii, p. 378, 1880, *non* G. O. Sars, 1878.

Cyclostrema Dalli Verrill, these Trans., v, p. 532, pl. lvii, fig. 39, 1882; Expl. Albatross, Report U. S. Com. Fish and Fisheries for 1883, p. 569, pl. xxvii, fig. 99, 1885. Tryon, Manual of Conchology, x, p. 97, pl. 33, fig 100, 1888.

Cyclostrema fulgidus Dall, Bull Mus. Comp. Zoöl., xviii, p. 393, 1889, *non* (*Trochus fulgidus*) Jeffreys, 1883.

Cyclostrema fulgidum Dall, Bull. U. S. Nat. Mus., No. 37, p. 166, pl. lxiii, fig. 99, 1889.

About a dozen specimens have been recorded as found at five stations between N. lat. 41° 53′, W. long. 65° 35′ and N. lat. 38° 01′ 15″, W. long. 73° 44′, in 390–1188 fathoms, 1880–1886.

Specimens from very deep-water are not of so firm a texture as the typical examples, the entire surface appears chalky without much lustre, and the lines on the base are less distinct. There is little resemblance between *G. Dalli* and the figure of *Trochus fulgidus* as given by Mr. Jeffreys, who described that species as having the peritreme "not continuous or complete;" while *Dalli* has the peritreme continuous, attached to the body-whorl for a considerable distance so that the form of the aperture is somewhat modified, and the columellar margin is flattened so that it spreads slightly over the umbilical region. The umbilical chink or fissure appears channeled and is defined by a raised thread, as in other species of *Ganesa*.

Lissospira (Ganesa) ornata (Verrill).

Cyclostrema Dalli, var. *ornatum* Verrill, these Trans., vi, p. 255, pl. xxxii, fig. 17, 1884; Expl. Albatross, Report U. S. Com. Fish and Fisheries for 1883, p. 569, 1885.
Cyclostrema ornata Dall, Bull. Mus. Comp. Zoöl., xviii, p. 393, 1889; Bull. U. S. Nat. Mus., No. 37, p. 166, 1889.

One live specimen (No. 35610), station 2115, off Cape Hatteras, N. C., in 843 fathoms, 1883.

As the principal distinguishing feature of the species of this genus lies in the arrangement of the microscopic sculpture, I follow Mr. Dall in giving specific distinction to the varietal name. The umbilical fissure, margined by a raised thread, would place the species with *Ganesa* rather than *Tharsis* (see p. 113), as suggested by Professor Verrill.

Lissospira (Ganesa) abyssicola sp. nov.

Ganeza sp. Verrill, these Trans., vi, p. 202, 1884.
Ganesa sp. Bush, Bull. Mus. Comp. Zoöl., xxiii, p. 219, 1893.

As described by Professor Verrill, this species in general appearance resembles a true *Lissospira*, but the umbilical chink is channeled and defined by a raised thread and the aperture is modified by the body-whorl to which the peritreme is more attached than in typical species.

It is similar in form to *G. Dalli* but larger, without sculpture and with the columellar lip less flattened.

One dead specimen, station 307 Ag., east of George's Bank, in 980 fathoms, 1880, "Blake Expedition."

Lissospira (Ganesa?) rarinota sp. nov.

Shell smooth, white, semi-opaque, of firm texture, with brilliant luster so that it appears somewhat porcellanous. Whorls three, convex, with a single, delicate, raised, microscopic, spiral line just below the distinct suture, defining a narrow, inconspicuous, slightly concave or channeled, sutural area. Nucleus relatively small, little raised; body-whorl large; spire low. The form of the aperture and peritreme and the channeled umbilical chink, bordered by an inconspicuous, rounded thread, place this species with *Ganesa*, although the texture of the shell is firmer and more porcellanous than any of the other species referred to it. Just within the aperture and extending completely around it is a delicate, opaque white line, which in some places appears raised.

This may prove to be a *Cirsonella*, p. 120.

Greatest diameter about 2·2^{mm}; height, about 1·6^{mm}.

One dead specimen, among foraminifera, at station 2150, N. lat. 13° 34′ 45″, W. long. 81° 21′ 10″, in 382 fathoms, 1884.

Section **Granigyra** Dall. See p. 115.

Type, **Granigyra limata** (Dall).

Cyclostrema (*Granigyra*) *limatum* Dall, Bull. Mus. Comp. Zoöl., xviii, p. 395, 1889; Bull. U. S. Nat. Mus., No. 37, p. 166, 1889.

A single dead specimen, found among foraminifera, from station 2150, N. lat. 13° 34′ 45″, W. long. 81° 21′ 10″, in 382 fathoms, 1884, agrees, except in size, with Mr. Dall's description of his type from off Cuba, in 310 fathoms. My specimen measures about 2^{mm} in greatest diameter and about 2·5^{mm} in height, and in this respect comes nearer the *G. pruinosa* of Jeffreys, the measurements of which are given as "L. 0.175, B. 0.15."

Granigyra spinulosa sp. nov.

A single dead specimen, found among foraminifera, from station 2655, N. lat. 27° 22′, W. long 78° 07′ 30″, in 338 fathoms, 1886.

This is a larger shell than the preceding but is of the same size as the type-specimen of that species, of a delicate yellow color with the granulations of the surface much coarser and more prominent.

It has about three well-rounded, rather loosely coiled whorls, forming an elevated spire with relatively large, prominent nuclear whorl and very large body-whorl. Suture well-marked, rather deep. Umbilicus of good size, deep, with rounded walls. Aperture as in typical *Lissospira*, with the peritreme but slightly attached at the suture. Granulation of the surface very conspicuous, the granules, when seen in profile, appearing like little spines.

Greatest width, 2·5^{mm}, height the same.

Leptogyra gen. nov.

This genus is constituted for a group of three species of minute, semi-transparent, dull, dirty white or faintly brown shells covered with a thin, rather tough, delicate straw-colored epidermis, consisting of a few convex whorls forming an elevated spire with relatively large, smooth, slightly twisted nuclear whorl and large body-whorl. Suture deep, somewhat channeled. Umbilicus relatively large, round, deep, showing some of the whorls, with rounded walls.

Aperture very oblique, somewhat ovate. Peritreme simple, continuous, modified on the body-whorl into a thin glaze, sometimes in the adult having a free edge; strongly sinuate along the umbilical region and anteriorly, slightly angulated below, at the junction of the two lips; above, arching well upward, forward, then backward from the body-whorl forming a distinct sutural notch.

Interior of the aperture smooth and very lustrous, with the conspicuous, exterior, transverse lines showing through by transparency. There is no internal opaque line; in all the specimens the operculum is drawn well into the shell.

The operculum is very thin, circular, of a delicate horn-color, with central nucleus, of about seven whorls defined by a fine spiral line.

The animal of the type species is too much dried to dissect, the shell being removed by hydrochloric acid, but the radula shows exceedingly interesting features. The entire length is but about ·35^{mm} and the width about ·08^{mm}. It consists of numerous rows of very delicately colored teeth. In each row there is a long, rather broad, strongly hooked median tooth; on either side, three or four lateral ones of about equal size; all of these, when seen in profile, appear distinctly triserrate and the outer ones somewhat larger than the others; beyond, there is a series of between 30 and 40, long, very slender, marginal hooks.

Type, **Leptogyra Verrilli** sp. nov.

Plate XXIII. figs. 13, 13*a*.

Shell consisting of three whorls which form a moderately elevated spire with obtuse apex due to the scarcely raised nuclear whorl. The surface, below the nucleus, is covered with microscopic, impressed, spiral lines, and more conspicuous, sinuous, raised, irregular, transverse lines or wrinkles which are most distinct near the suture and upon the upper part of the whorls, in addition to the very fine lines of growth; on the middle of the body-whorl and on the base, the spiral striæ become broader so that the alternating spaces appear like raised threads. Operculum and radula described under the genus.

Greatest diameter of one of the largest specimens, about 1·5^{mm}; height, about ·9^{mm}.

Eight live specimens, station 2174, off Delaware Bay, in 1594 fathoms, 1884.

Leptogyra inconspicua sp. nov.

Shell consisting of about 2½ whorls, forming a little elevated spire with very obtuse apex (the nuclear whorl being coiled on the same plane as the succeeding one). Surface nearly smooth, slightly lustrous, having, besides the delicate microscopic growth lines, irregularly dispersed, ill-defined, sinuous wrinkles extending from the suture a little way below the summit of the whorls.

Greatest diameter, about 1·3^{mm}; height, about ·8^{mm}.

Two live specimens, station 2174.

Leptogyra eritmeta sp. nov.

Shell consisting of three whorls which are more loosely coiled than in either of the preceding species, causing the spire to appear more elevated and the suture not so deep. Nuclear whorl very prominent. Surface below the nucleus, crossed by prominent, regular, evenly separated lines or threads which extend from suture to suture and over the base well up into the umbilicus, but are not so conspicuous here as on the upper part of the whorls. Under a high power, the summit of these appears uneven or very inconspicuously serrate.

Greatest diameter, about 1·5^{mm}; height, about 1^{mm}.

One live specimen, station 2174. It is an interesting fact that all three species were found at the same station.

Mölleriopsis gen. nov.

Shell small, relatively thin, white under a golden brown or olive brown epidermis. Whorls few, convex, forming an elevated spire and large body-whorl. Suture distinct. Umbilicus of moderate size, round, deep, showing some of the whorls. Aperture circular, slightly oblique; peritreme continuous with a thin, sharp edge, appearing thickened within, attached to the body-whorl only for a short distance. Animal and operculum not known.

This genus is proposed for a very deep-water shell which closely resembles *M. costulata* (Möller) Jeffreys, the type of the genus *Mölleria*, in several features, as the form of the aperture and peritreme and especially in the conspicuous carination of the base bordering the umbilicus; but differs from that rather solid, strongly sculptured species in being much larger, of more delicate texture, with a nearly smooth surface. The *Cyclostrema sulcatum* Watson (*non* A. Adams, 1850) = *Watsoni* Tryon, 1888 (Report Voy. Challenger, Zoöl. Scaphopoda and Gasteropoda, xv, p. 121, pl. viii, fig. 11,

1885), a very small species from off Brazil, in 675 fathoms, and *Adeorbis sincera* Dall (Proc. U. S. Nat. Mus. xii, p. 338, pl. xii, f. 2, 1889), from off Florida and Brazil, in 294 and 391 fathoms, have several features in common with the above deeper water form and can doubtless be referred to the same genus.

Type, **Mölleriopsis abyssicola** sp. nov.

Figures 6, 7.

One dead, imperfect specimen (No. 52496), station 2572, N. lat. 40° 29′, W. long. 66° 04′, in 1769 fathoms, 1885.

Fig. 6.

Fig. 7.

Shell small, opaque white, under a golden brown epidermis, of few convex whorls (the tip is broken away) forming a well-elevated spire and large body-whorl. Surface lustrous where rubbed, ornamented with a single conspicuous carina which defines a broad, flattened sutural area and makes the whorls slightly angulated. This is roughened by the crossing of the growth lines, which are elsewhere inconspicuous. On the base surrounding the umbilicus there are also four more prominent carinæ, about equal in size and evenly separated by wide, slightly concave interspaces; the first one, situated about the middle of the base, and the last one well up in the umbilicus; on all of these the lines of growth are so conspicuous as to give them a distinctly beaded appearance; at their termination they form distinct points on the somewhat expanded thin edge of the peritreme. The aperture within is dull, opaque white, with a narrow, much thinner, semi-transparent, somewhat expanded, sharp-edged border. This gives the appearance of thickening, but there is no raised opaque white line, said by some author to be the distinguishing character of *Mölleria*.

Greatest diameter, about $3{\cdot}2^{mm}$; height of body-whorl, about $1{\cdot}8^{mm}$.

Choristella gen. nov.

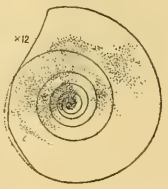
Figure 8.

This genus is proposed for two species of small shells of few convex whorls forming a flattened, little elevated spire with minute, scarcely raised, nuclear whorl and large body-whorl. Suture very deep, somewhat channeled. Umbilicus small, round, deep, showing

some of the whorls with rounded walls. Aperture oblique, nearly circular. Peritreme simple, continuous, slightly attached to the body-whorl, reflected over the umbilicus.

Operculum (fig. 8) of the type species is thin, round-ovate, delicate horn-color, of few abruptly enlarging whorls indistinctly defined by a spiral thread and showing sinuous transverse lines of growth, nucleus slightly excentric.

Fig. 8.



The animal has a broad emarginate head with one pair of long slender tentacles; with a rather broad, short, tapered, ciliated verge just beneath the base of the right one. Eyes none. Gill attached to the left side lying across the top of the body just within the mantle edge. Jaw plates thin, delicate horn-color with a broad band of very dark brown along the strongly serrate, cutting edges. Inner surface strongly reticulated, as in species of *Velutina*. The form of these plates is quite irregular: the cutting edge is oblique, forming an angle of about 135° with the inner or middle, straight edge; the distal outline is very strongly sinuously curved, forming a wide, shallow upper portion and a much narrower basal portion.

The radula (pl. xxiii, fig. 16) consists of numerous rows of delicate colored, rather stout, non-serrate teeth, each row having a series of thirteen:—a very small central or median tooth with rather long, strongly curved tip, placed a little above and alternating somewhat with the rest of the series; on either side, one broad strongly hooked lateral, and a much broader second lateral one with correspondingly broad, more pointed hook; beyond, three, about equal, much narrower, somewhat sickle-shaped, marginal ones with a small triangular, scarcely perceptible, platelike one on the outer edge.

The form of the shell and operculum strongly resemble a *Choristes elegans* var. *tenera* Verrill of medium size, but the radula shows marked and interesting differences. In that species, or rather variety, there are but eleven teeth in each series, the second or outer lateral tooth having a double or bilobed tip (these Trans., v, p. 541, pl. lvi, figs. 27, 27*a*, 1882; vi, p. 256, pl. xxix, figs. 9–9*b*, 1884.

Type, **Choristella leptalea** sp. nov.

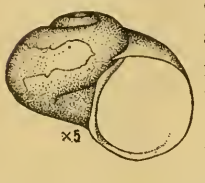
Figure 9. Plate XXIII. figs. 16, *a*.

Shell without sculpture, dull opaque white, of very delicate texture, consisting of about three and a half whorls. Operculum, animal, and odontophore described under the genus.

Greatest width, about 3·5^{mm}; height, about 2·5^{mm}.

One imperfect, live specimen (No. 52504), station 2547, off Martha's Vineyard, in 390 fathoms, 1885.

Fig. 9.



Owing to the very interesting character of the odontophore I have ventured to make this shell, although imperfect, the type of a new genus which is closely related to *Choristes*, for which Professor Verrill constituted the family Choristidæ and placed it among the Tectibranchiata. Mr. Dall (1889) placed it between family — ? genus *Separatista* Gray and Calyptrasidæ, genus *Mitrularia* Schumacher, etc.

Choristella brychia sp. nov.

Figure 10.

This is a larger species of firmer texture than the preceding, although of the same number of whorls. Sculpture none. Color dirty white tinted with brown. Where not worn, the surface is slightly lustrous. Interior of aperture very smooth and lustrous, showing a sutural band of delicate rose color. Greatest width, about 4^{mm}; height, about 3^{mm}.

Fig. 10.

One dead, imperfect specimen, station 2234, off Martha's Vineyard, in 810 fathoms, 1884.

The *Cyclostrema pompholyx* Dall (Bull. Mus. Comp. Zoöl., xviii, p. 394, pl. xxviii, fig. 9, 1889), may prove to be another species of this genus.

Cyclostremella gen. nov.

Shell minute, thin, semi-transparent, when fresh, planorbiform, of few convex whorls, nearly symmetrically coiled, forming a concavely depressed spire and large umbilical cavity. Epidermis thin, nearly colorless. Nuclear whorl relatively large, smooth, turned downward, seen only in a basal view, leaving a small pit above. Suture deep and channeled. Aperture triangular-ovate, expanded below, angulated above, with a relatively wide deep sinus just below the suture. Peritreme thin, simple, continuous, not modified, slightly attached.

The dark animal was drawn well into the shell. The operculum is very thin, almost colorless, broad-ovate, with the nucleus below the center and represented by a small smooth space indefinitely

defined by an indistinct line. From this arise numerous raised lines in the direction of the lines of growth, which are at first near together but diverge toward the outer margin, where they terminate just within the edge. Others arise between these about two-thirds their length.

Two large black eyes, close together on the top of the head, were the only feature that could be discerned in the much dried animal, the shell being removed by acid. The radula could not be found.

Type, **Cyclostremella humilis** sp. nov.

PLATE XXII. figs. 8–8*b*.

Shell minute, white, nearly smooth, consisting of two whorls, besides the nucleus. Surface somewhat shining, but under the microscope it is covered with rather conspicuous sinuous lines of growth which are crossed on the peripheral region by several raised, unequally separated, spiral threads, varying in number in different specimens, so that in some they extend farther above and below than in others.

Diameter of one of the largest specimens, about $1{\cdot}5^{mm}$; height, about $\cdot7^{mm}$.

One live and several dead specimens at stations 2112, 2274, 2277, 2278, off Cape Hatteras, N. C., in $15\frac{1}{2}$–16 fathoms, 1883–1884.

Lissospira profunda (Friele). See page 130.

A specimen of *Cyclostrema profundum* sent to Professor Verrill by Dr. Friele is much more transparent than any species from our coast which has been referred to *Lissospira*. The three very convex whorls form a small, elevated spire and abruptly enlarged body-whorl. The nuclear whorl is smooth, below which the entire surface is covered with numerous, raised, rather regular, evenly separated spiral lines which, under the microscope, are crossed and inconspicuously roughened by regular, raised, transverse lines which are more evident on the interspaces; the spiral sculpture becomes coarser on the base. The umbilicus is of moderate size, deep. The aperture is circular; the peritreme is slightly injured but shows that it is continuous and slightly attached to the body-whorl. The operculum is also typical.

Greatest diameter, about $2{\cdot}5^{mm}$; height the same.

Yale University Museum, July, 1897.

EXPLANATION OF PLATES.

Plate XXII.

Figure 1.—*Delphinoidea serpuloides* (Montagu) Brown. p. 100. Front view of a specimen (No. 9450) from Guerusey, England, in the Yale University Museum; × about 22.

Figure 1a.—The same. Basal view of another specimen from the same locality; × about 22.

Figure 1b.—The same. Top view of another specimen from the same locality; × about 22.

Figure 2.—*Lissospira diaphana* (Verrill) Bush, p. 131. Basal view of the type specimen (No. 38409) from station 2084; × 12.

Figure 3.—*Lissospira proxima* (Tryon) Bush, p. 130. Front view of the type specimen (No. 38443) from station 2115; × 12.

Figure 4.—*Cyclostrema cancellata* Marryatt, p. 97. Top view of the type specimen.

Figure 4a.—The same. Basal view. Both are enlarged copies of the original figures.

Figure 5.—*Adeorbis subcarinatus* (Montagu) Wood, p. 102. Top view of the nuclear whorl of the same specimen as figure 9; × about 35.

Figure 6.—*Circulus trilix* Bush, p. 127. View of an animal with operculum, from station 2280; the shell having been removed with nitric acid; much enlarged.

Figure 7.—*Vitrinella multistriata* (Verrill) Bush, p. 124. Top view of a young specimen (No. 35733) from station 2109; × about 16.

Figure 8.—*Cyclostremella humilis* Bush, p. 141. Basal view of one of the type specimens; × about 22.

Figure 8a.—The same. Front view of another specimen; × about 22.

Figure 8b.—Top view of another specimen; × about 22. All are from station 2278.

Figure 9.—*Adeorbis subcarinatus* (Montagu) Wood, p. 102. Basal view of a specimen (No. 9428) from Guernsey, England, in the Yale University Museum; × about 14.

Figure 10.—*Circulus trilix* Bush. Basal view of an adult (type) specimen (No. 35365) from station 2113; × 12.

Figure 10a.—The same. Front view of the same specimen; × 12.

Figure 11.—*Vitrinella Tryoni* Bush, p. 123. Front view of the type specimen from station 2278; × about 16.

Figure 11a.—The same. Top view of the same specimen; × about 16.

Figure 12.—*Circulus trilix* Bush. *a*, *b*, *c*, Camera-lucida drawings. *a*, Portion of the radula; greatly enlarged. *b*, A series of marginal teeth which turned outward in mounting; much enlarged. *c*, A single marginal hook; more enlarged. *d*, *e*, *f*, *g*, Free hand drawings. *d*, Broad median tooth; *e*, slender lateral tooth; *f*, series of twenty or more sickle-shaped, marginal teeth as seen when magnified about 1,000 diameters. *g*, Series of marginal teeth with the invisible lower lines introduced.

Figures 2, 3, 10, and 10a, drawn by J. H. Emerton; figures 6 and 12, by the author; the others, by A. Hyatt Verrill, are camera-lucida drawings (except figures 4, 4a).

Plate XXIII.

Figure 1.—*Circulus supranitidus* (Wood) Jeffreys, p. 127. Front view of an authentic specimen from the "Crag"; × about 18.

Figure 2.—The same. Top view of another specimen (smooth variety) from the same locality; × about 20. Both are from the U. S. National Museum.

Figure 3.—*Circulus Dalli* Bush, p. 126. Front view of the type specimen; × about 12.

Figure 3a.—The same. Basal view; × about 12.

Figure 4.—*Vitrinella multistriata* (Verrill) Bush, p. 124. Basal view of an adult specimen (No. 35733) from station 2109; × about 10.

Figure 5.—*Skenea planorbis* (Fabricius) Fleming, p. 100. Basal view of a specimen from Provincetown, Mass.; × 15.

Figure 6.—*Circulus Dalli* Bush. Top view of the early whorls of the type specimen; × about 17.

Figure 7.—*Circulus liratus* (Verrill) Bush, p. 125. Top view of the nuclear whorls of a young specimen from station 2277; × about 20.

Figure 8.—*Skenea planorbis* (Fabricius). Top view of another specimen from Provincetown, Mass; × about 15.

Figure 8a.—The same. Front view of another specimen from the same locality; × about 13.

Figure 9.—*Vitrinella helicoidea* C. B. Adams, p. 122. Top view of a specimen from station 2280; × about 13.

Figure 9a.—The same Front view of the same specimen; × about 13.

Figure 10.—*Circulus trilix* Bush, p. 127. Front view of a young specimen from station 2276; × about 20.

Figure 11.—*Circulus Duminyi* (Requien) Jeffreys, p. 125. Front view of a specimen from Naples; × 11. From the U. S. National Museum.

Figure 12.—*Circulus liratus* (Verrill) Bush, p. 125. Front view of a young specimen from station 2277; × about 15.

Figure 12a.—The same. Basal view of the same specimen; × about 16.

Figure 12b.—The same. Top view; × about 13.

Figure 13.—*Leptogyra Verrilli* Bush, p. 136. Front view of one of the type specimens from station 2174; × about 19.

Figure 13a —The same. Basal view of another specimen from the same station; × about 19.

Figure 14.—*Vitrinella multistriata* (Verrill) Bush, p. 124. Front view of a young specimen from station 2109; × about 10.

Figure 15.—*Circulus trilix* Bush, p. 127. Top view of the early whorls of a specimen from station 2276; × about 22.

Figure 16.—*Choristella leptalea* Bush. p. 139. Camera-lucida drawing of a portion of the radula; greatly enlarged. *a*, One of the marginal teeth which was turned outward in mounting.

Figure 16 is by the author; the rest are camera-lucida drawings by A. Hyatt Verrill.

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IV.—Revision of certain Genera and Species of Starfishes with descriptions of new forms. By A. E. Verrill.

Family GONIASTERIDÆ.

Goniasteridæ Verrill, Trans. Conn. Acad. Sci., i. p. 343, 1867; Perrier, Revision, Arch. Zool. Exper. et Gen., iv. pp. 281, 283, 289, 291, 1875; op. cit., V., p. 1, 1876.
Goniasteridæ (*pars*) Forbes, 1840.
Pentacerotidæ (*pars*) Gray, p. 275, 1866.
Pentagonasteridæ Perrier, 1884; Sladen, p. 260, 1889.

The generic nomenclature in this family has become very much confused for several reasons.

The genera themselves are difficult to limit and define, and scarcely any two investigators, in the past, have agreed as to their number or limits. Nor have they agreed as to what characters should be considered as of generic value. This was the case, in a very marked degree, and very unfortunately, when the ancient and comprehensive genus *Asterias* was first divided into numerous genera by J. E. Gray, in 1840, and by Müller and Troschel, in 1842. In these two works, issued within a brief period, there was very great diversity, both as to the number of genera and their names. In the genus *Astrogonium* of M. and Tr. *four* of Gray's genera were reunited into *one*. In *Goniodiscus* M. and Tr., *five* of his genera were also reunited. For about half a century most subsequent authors have tried to take an intermediate course, but gradually more and more of Gray's genera have been adopted, though often with their limits more or less modified. Fortunately Gray assigned definite types to his genera, and in his later works he described and figured many of the species, so that in most cases his groups can be readily understood. Moreover he followed, pretty closely, the generally accepted rules of zoological nomenclature, which has not always been done by later writers.

The failure of several writers to follow the ordinary and accepted rules of priority has led to much needless confusion of names. The failure to recognize the priority of Gray's generic names has been the cause of more confusion than any other one thing, throughout the group of starfishes.

The efforts that certain writers have made, from time to time, to restrict or apply certain generic names to species or groups to which they were not originally given, has repeatedly led to confusion and

uncertainty. This applies strikingly to *Goniaster*, *Astrogonium*, *Dorigona*, etc.

A few recent and prominent writers, especially Perrier and Sladen, have restored the ancient names given by Linck (1733) to certain genera and species of starfishes, thus displacing names well established under the binomial system. Linck was a very able naturalist, for his period, but he was not a binomial writer, and his names cannot properly be allowed priority over those established under the binomial system.

The name *Pentagonaster* is the only generic name in this family to which this remark applies.

Perrier himself, although he restores several of Linck's names of species, does not go so far as to try to restore others that have equal claims to priority, for to do this would overthrow the well known names of several common European species.* Nor has he proposed to restore the names of Seba, which have equal claims to recognition.

In the following pages I propose to briefly review the history of some of the earlier names and of the more important groups to which they have been applied by various writers, in order to show, if possible, to what particular groups certain of these names ought rightly to be applied, in accordance with the generally accepted rules of biological nomenclature.†

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* Among the names adopted by Perrier, and also by Sladen, from Linck, are *oculata*, under *Cribrella; planus*, under *Hippasterias; corniculatus*, under *Ctenodiscus*. Neither of these can be justified.

† Among the recognized rules that I follow, and which need to be applied to this group, are the following:

A.—Strict priority to be applied to all names properly published in actual *binomial works*, in general dating only from Ed. X. of the Syst. Nat. of Linné.

B.—Exclusion from the rule of priority of names taken from earlier polynomial writers, unless adopted by later binomial writers. In that case they should date only from their introduction into binomial literature.

C.—When an old composite genus has been divided by a later writer, the original name must be kept for one of the component groups, and for one or more of the species originally included *by name*. If a definite generic *type* was given by the original author, the name must remain with that type. If *no type* was mentioned, the mere position on the page cannot fix the type. Nor does it follow that the *first* species named was the type, unless so stated originally, for many early writers arranged their species alphabetically, or in some other arbitrary way.

D.—A composite genus having been subdivided and the original name definitely applied to one of its parts (in accordance with rule C), it must ever after be kept for that group (or some part of it) just the same as if it had been originally so

This brief review is, however, by no means intended as a complete history of the subject. Generally only the works that seem essential to the object in view will be referred to here. A fuller discussion must be left to a much more extensive work on American starfishes, which is now well advanced towards completion and in which most of the genera and species will be well illustrated.

1. The first generic name applied by binomial writers to any subdivision of the old genus *Asterias* (Linné), and pertaining to the present family, was *Goniaster*. This name was proposed by L. Agassiz, in 1836, for the pentagonal starfishes, collectively, including representatives of more than one family.

This name was adopted by Forbes in 1841 (Brit. Starfishes), in the same sense, for he included in it such diverse forms as *Hippasteria* and *Asteropsis*, without assigning to it any definite type. Müller and Troschel used it in the same way, in 1840. Dr. J. E. Gray, in 1840, adopted the name for a very restricted group, with a definite diagnosis, and named as a type, *G. cuspidatus*, a well-known species and one of those given by Agassiz as examples of his genus. This species should, therefore, remain as the type of the restricted genus.

In 1842, Müller and Troschel reunited *Goniaster*, *Pentagonaster*, *Tosia*, and *Hippasteria* of Gray into a single genus, to which they applied the new name, *Astrogonium*. If these four groups really constitute only a single genus, it is evident that *Goniaster* (emended) should have been adopted as its name.

II. The name *Pentagonaster* was first used, under the binomial system, by Gray, in 1840. He applied it to a particular type (*P.*

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applied. In other words, a generic name correctly applied to a restricted group has just as much claim to priority, *in the new sense*, as a *new name* would have.

E.—When a generic name is a *real synonym* of another earlier one it should be dropped from the system, unless it had a different type-species when first proposed. In case the two types belong to different subdivisions of a composite genus both names may be retained in a modified sense. In cases where two names are only *partially* synonymous, both may be used if they can be properly restricted to distinct subdivisions of the groups to which they may have been originally applied (in accordance with rule C).

F.—The application of an old or discarded name to a species or group not included in the group to which it was originally applied is to be avoided as leading to confusion and instability. A name once dropped from the system, for good cause, should fall into disuse in every other sense. To use a discarded generic name for a new genus in the same class or order (as if it were a new name), should never be thought of, for it is sure to cause confusion. (*Goniaster* and *Astrogonium* among starfishes afford examples of incorrect transposition of names.)

pulchellus) and gave it a definite diagnosis. His use of the name should, therefore, have priority, and the name should not be applied to any other group, unless *P. pulchellus* be included in a larger generic group, as was done by Perrier, in 1876, and by Sladen. But in the latter case, *Goniaster* should have had precedence over *Pentagonaster*, for such a comprehensive group, on the ground of priority.

In a later work (1894) Perrier separated Gray's *Pentagonaster* as a distinct genus, but he ignored the original application of the name by Gray, and adopted the later name, *Stephanaster* of Ayres, for Gray's genus.

At the same time he retained *Pentagonaster* for a large group of species closely allied to *P. australis*, which was the type of *Tosia* Gray, 1840. This arrangement was based on the fact that Linck, in 1733, had figured an indeterminable species, apparently of the latter group, under the name of *Pentagonaster*. But Linck, however great his merits may have been, was certainly not a *binomial* writer. Most of his names were trinomial or polynomial, and there is nothing to be gained, except increased confusion, by trying to give priority to the names used by such polynomial writers, in place of later binomial names that have been definitely defined and fixed in the binomial system.

Perrier, in 1876, restricted *Goniaster* to a genus containing only a single species, *Pentaceros obtusangula* (Lam.) Gray. This species was not mentioned by Agassiz in connection with the genus *Goniaster*. Its use by Perrier is, therefore, in a new sense and like that of an entirely new name, and was not justifiable.*

Sladen (1889) has also restricted *Goniaster* to the same type.

III. *Tosia* was also proposed by Gray, in 1840, for a definite group of this family, with *T. australis* as the type. Several other species were added to it by him in 1847. This name has been ignored by most later writers on starfishes, or else it has been placed as a partial synonym of *Pentagonaster* (Sladen, Perrier) or *Astrogonium* (M. and Trosch.). If Gray's restricted genus *Pentagonaster* be deemed a valid one, as by Perrier (1894), then *Tosia* should be used for the large group of species, called *Pentagonaster* by Perrier and Sladen, agreeing well with Gray's diagnosis and type-species (*T. australis*).

IV. *Hippasteria* was proposed by Gray, in 1840, for the single type-species, *H. phrygiana* (as *H. Europæa*, etc.). This name has been so generally adopted by later writers that it needs no discussion here.

* The restriction of *Goniaster* to its correct type leaves this genus without a name. Therefore I would propose for it *Pseudoreaster*, with *P. obtusangulus* (Lam.) as its type and only known species.

V. *Calliaster* proposed by Gray, in 1840, for the single type-species, *C. Childreni*, is very distinct from the genera already named, not only on account of the spinose plates of both surfaces, but also by reason of its very different adambulacral spines.

VI. *Hosia.* When Gray established this genus, in 1840, he referred to it only *H. flavescens.* Perrier (1876) has redescribed the types of this species and refers them to two distinct species of true *Anthenea* (Gray, 1840). Therefore *Hosia* becomes a synonym of the latter. In 1847 and 1866, Gray added another species (*H. spinulosa*) to *Hosia*, but according to Perrier (1876), who reëxamined Gray's type, this species belongs to a different genus. He referred it to his section C of *Pentagonaster.* It has spinulose marginal plates, and also valvular pedicellariæ. It is probably an immature species of *Tosia*, or of some closely related genus.

VII. The names proposed by Müller and Troschel, in 1842 (Syst. Ast.), are next in order.

Astrogonium, as stated above (p. 145), was formed by uniting four of Gray's genera. It thus became a composite group without any definite type, and not very different from the original group called *Goniaster* (1st section) by Agassiz. In 1847 and 1866, Gray applied the name to a more limited group, including *A. granularis* (Retz.), which is nearly allied to *Tosia*, together with species now referred to *Odontaster.*

If it were to be used at all in the modern system, it should be restricted to the group containing *A. granularis.* But as it was an artificial group and should have had no real status originally, it should properly drop out of use except as a synonym of Gray's genera.

By Sladen (1889) *Astrogonium* was restricted to Gray's genus *Pentagonaster*=*Stephanaster* Ayres.

Perrier (1894) has used it improperly for a very different group, (=*Pseudarchaster*+*Aphroditaster* Sladen), including several deep-sea species, none of which were known to M. and Troschel, nor to Gray.

VIII. *Goniodiscus.* M. and Troschel (1842) constituted this genus by reuniting five of Gray's genera, together with forms unknown to Gray. Perrier (1894) has very judiciously restricted the name to those species that have stellate or 6-lobed abactinal plates, included in it by M. and Trosch., such as *G. cuspidatus* (Lam.), and in this sense it should be adopted.

The genera proposed subsequently to those already mentioned have given rise to no great confusion and therefore need not be discussed here.

Goniaster (Agassiz), Gray (restr.). Type *G. cuspidatus* Agassiz.
Goniaster (*pars*) Agassiz, Prod. Mem. Soc. Neufch., 1836.
Goniaster Gray, Ann. and Mag. Nat. Hist., vol. vi, p. 280, 1840. Type *G. cuspidatus*. Synopsis, p. 10, 1866 (*non* Perrier, 1876, *nec* Sladen, 1889).
Pentagonaster (*pars*) Perrier, Revis., Arch. de Zool., v, p. 24, 1876. Sladen, Voy. Chall., xxx, p. 264, 1889.
Astrogonium (*pars*) Müll. and Trosch., Syst., pp. 52, 56, 1842.
Phaneraster Perrier, Exp. Sci. Trav. and Talisman, pp. 334, 337, 387, 1894. (Type *G. semilunatus* = *cuspidatus*.)

As already explained, the genus *Goniaster* was restricted by Gray, in 1840, to a definite and well known type (*G. cuspidatus*). Perrier, in 1894, has, quite unnecessarily, applied a new name (*Phaneraster*) to exactly the same group, with the same type. Whether *Goniaster*, as here restricted, is worthy of generic separation from the great group called *Pentagonaster* by Perrier and by Sladen, must remain, for the present, a matter of personal opinion, but if they should be reunited under a single generic name, *Goniaster* would be the name that ought to be chosen for the whole group, if we are to follow the generally accepted rules of binomial nomenclature. (See above, p. 146.)

The principal character by which the present group has been distinguished is the presence of one or more large, stout conical tubercles or spines on more or less of the dorsal marginal and abactinal plates, in adult specimens; or of verruciform swellings in the same situations, in the young. In most adults these conical spines form a central group on the disk and five large radial groups, but the number of plates that may bear spines is variable; sometimes they occur on nearly all the dorsal plates.

The marginal plates are large, thick, convex, not numerous, and usually naked, except for one or two marginal series of granules, but they are more or less granulous over the surface in the very young. They are more numerous in the ventral series. Those in the dorsal series may not decrease regularly distally; the last one is sometimes as large as, or even larger than, the one that precedes it. The apical plate is small, conical. The actinal plates are large, polygonal, and crowded, mostly in series parallel with the adambulacral plates, and covered with coarse granules; the granules on the center of the plates are often larger and may be like small tubercles. Sometimes part or all of these plates bear high, slender, spatulate pedicellariæ. The adambulacral plates and spinules and the dentary plates are essentially the same as in *Pentagonaster* or *Tosia*. The adambulacral spinules are numerous and closely crowded in three or more rows; the row next to the furrow-series is largest.

The abactinal plates are rather large, polygonal or roundish, covered with crowded, short, angular granules, with a larger marginal series; sometimes they also bear pedicellariæ. Between these there are often, in adults, many small ossicles, usually bearing groups of few granules. Papular pores are present between most of the abactinal plates, except in the small interradial areas.

In adult specimens some of the distal, lower, marginal plates bear small conical spines or tubercles, in some species.

Pedicellariæ have been observed only in *G. Americanus*, where they are sometimes numerous, both on the actinal and abactinal plates, and they occur also on the sides of the dorsal spines and marginal plates. They are small, high, slender, pincèr-shaped, with spatulate blades and corresponding sockets on the plates. (See below.)

Perrier erroneously states (1894) that pedicellariæ are not found in this genus. They were described by me in 1871.

When very young (up to 12 or 14^{mm} in diameter) there is no appearance of dorsal spines or tubercles and the marginal plates are few in number and granulated. In this stage there appears to be no obvious distinction between this genus and *Pentagonaster* or *Tosia*.

Such specimens were mistaken by Perrier for a distinct species (*Pent. parvus*). They will be more fully described on a later page.

Goniaster Americanus Verrill.

Goniaster Americanus Verrill, Amer. Journ. Sci., vol. ii, p. 230, 1871.
Pentagonaster semilunatus (*pars*) Perrier, Arch. de Zool. exper., v, p. 24, 1876.
Phaneraster semilunatus (*pars*) Perrier, Sci. Exp. Trav. and Talis., p. 388, 1894.
Pentagonaster parvus Perrier, Mem. Etoiles de mer, Nouv. Archives du Mus. d'Hist. Nat., vi, p. 231, pl. vii, figs. 7, 8, 1884. (Young.)

Plate XXIV*a*. Figures 1, 2. Plate XXVI. Figures 1-6.

This species was originally described by me so minutely that it is not necessary to repeat the general description of the adult. The type was from rather shallow water, off the coast of South Carolina.

This type specimen, which is in the museum of Yale University, has a large number of high, pincer-like pedicellariæ, with two slender spatulate or spoon-shaped blades, and a slightly enlarged articulating base; the blades are sometimes straight, but often more or less strongly curved to the right or left. The blades, when fully expanded, rest in socket-like depressions of the plates, which correspond in shape and curvature with the blades, so that the two belonging to a pedicellaria with curved blades, form, when taken

together, a crescent-shaped or semicircular pit, with a round central pore and a wider rounded depression at each end. Sometimes one or two granules exist close to the pedicellariæ, and when rubbed off the pits that they leave make the markings on the plates still more complex.

Pedicellariæ of this peculiar form are present on a large proportion of the actinal plates; on some of the marginal plates; on the borders of the spinose abactinal plates, around the bases of the spines, 1 to 6 on a plate; on the basal part of the spine itself; and on those abactinal plates that do not bear spines, 1 to 4 or more.

On the actinal plates they are variously placed, and irregularly oriented; most of the plates have but one, which is most commonly near the center, but many have two; those plates in the row next to the adambulacral plates usually have two or three. The pedicellariæ on the abactinal plates and on the spines are smaller than those of the lower surface, but have the same form and similar sockets. Each pedicellaria of the actinal and abactinal plates occupies a small, slightly elevated, smooth, rounded or ovate area, surrounded by granules. A pedicellaria and a stout blunt tubercle coexist on some of the actinal plates, near the jaws.

Between all the abactinal plates, except those of the small interradial areas, where there are no papular pores, there are small intermediate ossicles, the larger of which bear small circular or angular rosettes of about 5 to 9 prismatic, flat-topped granules, like those around the margins of the large plates. One to three of the granules occupy the center of these groups. Between these small rosettes there are many small irregular groups of two or three similar angular granules, intervening between the numerous and rather large papular pores, of which there may be ten or twelve around the larger plates.

The madreporic plate is very large, somewhat swollen, with fine gyri. The apical plate is small and conical, similar in size and form to the tubercles of the distal marginal plates.

The two distal pairs of dorsal marginal plates are in contact medially. On each of the distal adambulacral plates there is a single large, obtuse conical spine, outside the furrow-series of slender spinules. These spines are longer and larger than the more numerous corresponding spines of the more proximal plates. There are usually, in large specimens like the type, four stout, prismatic, blunt, crowded spinules on each plate, in the furrow-series, as in *G. Lamarckii*, instead of three, present in *G. cuspidatus*.

A fine series of specimens, of various ages, was dredged by the "Albatross," off Florida and in the West Indies.

Some of the variations noted among these are as follows:

A.—Station 2363. One large example.

Lesser radius, 35^{mm}; greater, 65^{mm}.

Most of the dorsal marginal plates, except distally, bear a high, acute, conical spine. On each ray the last dorsal marginal plate is elongated, subconical, with a small terminal spine. It looks as if it might have been about to divide into two or more plates; or as if two or more had abnormally consolidated. The distal lower marginal plates bear rudimentary conical spines. There is also a group of 2 to 4 small obtuse tubercles on each jaw, around the mouth. The abactinal plates bear a central group of 9 or 10 large, high, acute, conical spines and four or five rows of about 6 or 7 on each radial area, with shorter rows of 2 to 4 on each side of these.

B.—Station 2373. One large example.

Nearly normal, but 4 to 6 of the interradial plates have very large, stout, transversely compressed spines, bilobed at the tip.

C.—Station 2318. One very large.

Similar to A, with 18 or 19 pairs of marginal plates, the distal ones regularly decreasing. Three or four of the distal, dorsal marginal spines bear acute conical spines.

No tubercles around the mouth on the jaws.

D.—Station 2316. Six examples.

These vary in size from 40 to 54^{mm}, in larger radius. They have from 13 to 16 pairs of marginal plates on each side. All have tapered, acute rays, with a small conical apical plate. They agree pretty closely as to the lower surface. The more spinose examples have a central abactinal group of 6 or 7 conical spines and there are 4 to 6 (usually 5) spines in each radial row; nearly all the upper marginal plates have a single stout, conical spine. In others there are but 3 to 5 spines in each radial row; in some 8 to 10 spines are irregularly scattered over the abactinal surface. In some cases more or less of the spines have been broken off, leaving a smooth scar in their places. In some examples the dorsal marginal plates bear high, acute, conical spines; in others low, blunt, cones or tubercles with broad bases.

The lower marginal plates bear a variable number of spines, toward the end of the rays; most frequently there is a small group

of spines on the 4 or 5 distal plates ; in others only one ; in some none at all. These variations may occur on different rays of the same example.

E.—Station 2406. Three examples.

The two larger are much like those described above. The smallest has the smaller radius 15^{mm} ; the larger radius, 23^{mm}. It has 12 pairs of marginal plates on each side. The dorsal ones are thick, convex or rounded, and some are beginning to swell up in the middle to form tubercles or spines. The distal lower marginal plates show sub-conical elevations, where the spines are beginning to grow. Some of the abactinal plates show an elevation in the center, where the spines are beginning to develop.

F.—Station 2315. One example.

Similar in size to the one last described. Ten pairs of marginal plates on each side. They are of the usual shape and many of the dorsal ones show a central, low, conical elevation or rudiment of a developing spine. The abactinal plates are without evident tubercles.

G.—Station 2374. Four examples.

Similar to the last in size. Three have 10 pairs of marginal plates on each sides; the other has 12. Most of the dorsal marginal plates have conical or subspiniform elevations. The abactinal radial plates have 3 or 4 conical spines in a row, nearly like those of adult examples. There is also a central group of spines on the disk, sometimes as many as five.

H.—Station 2370. One, very young. (Specimen figured, Pl. xxv, fig. 6.)

The larger radius is 5^{mm}. Six pairs of marginal plates on each side. Apical plate broadly triangular. No marginal nor abactinal tubercles. Abactinal and actinal plates surrounded by a single series of granules.

I.—Station 2370. No. 18,457, specimen figured. One young example.

Radii 12 and 17^{mm}. Dorsal marginal plates 10 pairs on each side, all short, broad, strongly convex. Ventral marginal plates 14 on a side. Small, slender pedicellariæ with long spatulate blades occur on many of the actinal and abactinal plates. No trace of spines on the abactinal plates, which are finely granulated over the central area, with larger marginal granules; a few very small intermediate ossicles occur between them, each with 1 to 3 small granules. Papular pores are few and small, but scattered over most of the radial areas. The adambulacral spinules are in four longitudinal series; those next

to the furrow-series are distinctly larger than the others, two to a plate on the proximal half of the series; those of the furrow-series are slender, equal, obtuse, regularly placed in a row, four to each plate. One or two of the distal lower marginal plates of each series bears a small conical tubercle, but the dorsal plates are smooth, naked, without tubercles, though considerably elevated centrally.

I have also examined four young specimens of this species from the "Blake" Exp., preserved in the Museum of Comparative Zoölogy.

Three of these (*a*, *c*, *d*) were types of *Pentagonaster parvus* Perrier. They agree perfectly with those of similar size collected by the steamer "Albatross" in the West Indies. (See H and I above.) With the latter they form a complete series, connecting the smallest with the full grown examples from the same region.

The smallest of the specimens (*b*) from the "Blake" Exp. is from station 253. It is enumerated under *P. parvus* by Perrier, but is not marked as a type, but it agrees with the others. Its lesser radius is 7^{mm}; greater radius, 10^{mm}. In this there are, for the most part, four upper marginal plates, above and below, on each side; but in one case there is a small triangular plate interpolated between the first interradial and the next normal one, while there is a normal plate next the apical one, so that there are four marginal plates on one side of this ray and the adjacent semi-margin. On another interradial margin there is a small, triangular, odd interradial marginal plate of the upper series, similar to that in *Odontaster*.

The lower marginal plates are usually six to a side, but on one margin there are seven. The distal plate of some of the series is small and only recently developed. The marginal plates of both series are covered with granules. The papular pores are few in number, in small radial groups.

The specimens next in size are 25 to 35^{mm} in diameter (types of *P. parvus*) and usually have six marginal plates on each side, above and below. In the smaller of these the upper and lower marginal plates and the actinal interradial plates are nearly or quite covered with small granules, but in the somewhat larger specimens more or less of the central area of these plates is naked. Most of them show a distinct central swelling where the conical tubercles would have appeared later. In some the abactinal plates are entirely covered with granules, but in others the central area is naked, the amount of naked surface increasing with age, but not regularly so. The papular pores increase in number with age and cover more and more of the median radial areas and the central area of the disk, but these areas have no sharp boundaries.

List of Specimens of Goniaster Americanus taken by the Albatross, in the West Indies.

Station	2315,	37 fathoms,	No. 10071, 1, young.
"	2316,	50 "	10076, 6, young.
"	2318,	45 "	10821, 1, very large.
"	2318,	45 "	10876, 2, half-grown.
"	2363,	21 "	10618, 1, large.
"	2370,	25 "	----- 7, young.
"	2372,	27 "	----- 3, young.
"	2373,	25 "	10337, 1, large; 11, young.
"	2374,	26 "	10820, 6, young and half-grown.
"	2374,	26 "	10340, 5, young.
"	2406,	26 "	10459, 3, half-grown.
"	2407,	24 "	----- 6, young and old.

Specimens examined from the Blake Expedition.

a.	Station	32,	95 fathoms.
b.	"	253,	92 "
c.	"	276,	94 "
d.	"	296,	84–129 "

Goniaster Africanus Verrill.

Goniaster Africanus Verrill, Amer. Journ. Sci., vol. ii, p. 131, 1871.

Plate XXV. Figures 1, 2.

Perrier (Revis. 1876, p. 24) united this species and *G. Americanus* with *G. cuspidatus* of the East Indies. He showed very well, by his comparison of a large series of specimens, that the number and precise form of the dorsal spines and marginal plates are variable in specimens from each region and cannot be depended upon to separate the species.

It has long been known that the number of marginal plates in all starfishes increases with age, and that their shape also varies with age, also that the spines increase with age.

Perrier, however, did not make careful comparisons of the much more important characters to be derived from the size and character of the granules, tubercles, and spines of the plates; presence or absence and shape of pedicellariæ; form and character of the adambulacral spines; size and form of the small ossicles and granules between the abactinal plates.

In all these characters *G. Africanus* differs decidedly from *G. Americanus*, if the numerous specimens of the latter that I have

been able to examine are to be depended upon. I have not had a sufficient series of the East Indian *G. cuspidatus* for examination to warrant me in making so positive a statement as to its distinctness from *G. Africanus*, but the published descriptions indicate important differences.

In addition to the marked differences between *G. Africanus* and *G. Americanus* in the number and character of the dorsal spines and marginal plates, I wish to call attention to the following points. *G. Africanus* (type) has no pedicellariæ, above or below. The actinal plates mostly have a central cluster of three to six or more unequal rounded tubercles, much larger than the granules. No specimens of *G. Americanus* that I have seen have this character, though some of the largest ones may have one or two central tubercles, on a few of the plates near the mouth. The granules of the abactinal plates are much smaller than in the latter and are more rounded, with less differentiation of the marginal series. The small, intermediate abactinal plates seldom bear distinct rosettes of granules, but usually appear as small, round or oval, smooth-topped ossicles, on a level with the other plates.

In having the distal pair of dorsal marginal plates larger and more swollen than those that precede it, and largely in contact medially, this species agrees with *Pentagonaster pulchellus* and allied species. I have seen no specimens of *G. Americanus* having this character, nor is it said to occur in *G. cuspidatus*.

It is my intention to fully illustrate these species in another article, now in course of preparation.

G. Africanus is native of the West Coast of Africa.

G. Lamarckii (*Astrogonium Lamarckii* Müll. and Trosch., p. 56, 1842; *Pentagonaster Lamarckii* Per. (Revis., p. 29, 1876) is from an unknown locality. It has rounded dorsal marginal plates and seems quite distinct from the other species.

Pentagonaster Gray, 1840, 1866. Type *P. pulchellus* Gray.

Stephanaster Ayres, Proc. Boston Soc. Nat. Hist., iv, p. 118, 1851. Type *S. elegans* Ayres=*pulchellus* Gray.

Pentagonaster (Sect. A, *a*, *pars*) Perrier, Revision, Arch. Zool., V., p. 12, 1876.

Astrogonium Sladen, Voy. Chall., xxx, pp. 263, 285, 1889.

Stephanaster Perrier, Exp. Trav. and Talisman, p. 402, 1894.

The name *Pentagonaster* was first introduced into binomial nomenclature by Gray in 1840. By him it was definitely defined, and a well-known species was given as the type (see p. 147, above). Therefore, the name should be used for the group thus limited by him.

The following species apparently belong to the genus as restricted by Gray (1840):

P. pulchellus Gray. New Zealand to China.
P. abnormale Gray. Unknown locality.
P. Bourgeti Perrier. Cape Verde Islands.
P. Gunnii Perrier. Tasmania and Australia.
P. Dubeni Gray. South and West Australia.

Tosia Gray, 1840. Type *T. australis* Gray.

Astrogonium (*pars*) Müll. and Troschel, Syst., Ast., 1842.
Tosia Gray, Synopsis, p. 11, plates iii and xvi, 1866.
Pentagonaster (Sec. A, *b*, *pars*) Perrier, Revision, p. 20, 1876.
Pentagonaster (*pars*) Sladen, Voy. Chall., xxx, p. 264, 1889. Perrier, Exp. Trav. et Talism., pp. 389, 390, 1894.

Under the ordinary rules of priority, in zoological nomenclature, there is no valid reason why *Tosia* should not be adopted for a large part of the species included by Perrier and by Sladen in the genus *Pentagonaster*, providing we are to consider this group generically distinct from *Pentagonaster* Gray. This question of the generic distinction must still be regarded as doubtful by many students of the group, though Perrier, in his later works, has definitely separated them, as shown above.

The only obvious difference, hitherto pointed out, that may be considered as of generic value, is the gradual decrease in size of the marginal plates distally, so that the rays are sub-acute, instead of the distal ones being larger and swollen, as in the true *Pentagonaster*.

But there are species of the latter in which the distal plates are only slightly larger than the others, while the amount of decrease in the plates of the species of this group is variable. Moreover in the restricted genus *Goniaster*, one species (*G. Africanus*, type) has the distal dorsal plates more swollen and larger than those that precede it.

Nevertheless, since the marked enlargement of the distal plates indicates a different law of growth in species so characterized, it seems desirable to keep the two groups separate, at least until truly intermediate forms become known.

In the typical species of *Tosia*, the marginal, abactinal, and usually some of the actinal plates have a naked central area, with one or more rows of granules around the margin. But the extent of the granulation varies more or less individually, and also according to the age of the specimen. Therefore we cannot regard this as a matter of much importance, generically.

The typical species appears to be destitute of pedicellariæ, but small, high, pincer-like pedicellariæ, with spatulate blades or chisel-shaped blades, occur in many of the allied species more recently described (e. g. *Perrieri*, *Vincenti*, *hæsitans*).

In many of the species of this group all the dorsal marginal plates, except the last or two last pairs, are separated by one or more rows of abactinal plates. But in several deep-sea species (*Perrieri*, etc.) three to five distal pairs of marginal plates are in contact medially. In some species different individuals have been found to vary, in this respect, from those having only one pair joined, to those with three or four pairs joined.

Considerable variations also occur among the species, in respect to the character and arrangement of the adambulacral spinules, in the number and arrangement of the papular pores, and in the form of the abactinal plates.

Most of these characters are not sufficiently constant nor important for generic divisions, but may well afford grounds for dividing the group into convenient sections. (See p. 160.)

Sladen, in his great work on starfishes, included in his genus *Pentagonaster* not only those that are here separated as typical *Goniaster*, but also others that apparently belong to *Mediaster* and *Hoplaster*, besides some that belong perhaps to undescribed genera.

To *Mediaster* I refer three of his new species : viz. *P. Japonicus*, *P. Patagonicus*, and *P. arcuatus*. But as the existence of internal connecting ossicles between the abactinal plates has not been ascertained for either of these species, this reference is based on the general appearance and on the character of the plates, spinules, and pedicellariæ.

His *P. lepidus* appears to be a true *Hoplaster*. It has odd interradial marginal plates and all the plates are spinulose. *P. gibbosus* Perrier also appears to be generically distinct, as well as *P. intermedius* and *P. dentatus*. If these forms be eliminated, the genus becomes more homogeneous and better capable of definition, though it still remains an extensive group.

Perrier, in his later works, has generically separated numerous species that he formerly referred to *Pentagonaster*, such as *Rosaster*, *Odontaster*, and the forms that he refers to *Dorigona*. But some of the other species that he has described as belonging to this genus, especially *P. intermedius* and *P. dentatus*, also appear to be worthy of generic distinction.

In this article, I have constituted several new genera to include some of these peculiar forms, hitherto referred to *Pentagonaster*, together with some new species.

Tosia Gray, emended.

The genus *Tosia*, as here limited, will include not only the typical group of species named by Gray, in which more or less of the marginal and abactinal plates are naked in the middle, but also those that are granulated over the whole surface, as in *granularis* and its allies, the extent of the granulation having been found to be variable in many species. In each section there are species with pedicellariæ and others in which they appear to be lacking.

The marginal plates are regular and generally correspond pretty closely in the upper and lower series, except distally; an odd interradial plate sometimes occurs abnormally. Apical plate small.

The abactinal plates of the radial areas are polygonal, most often hexagonal, or roundish, crowded pretty closely together, without distinct, intervening, connecting ossicles and without secondary plates of small size.

The papular pores are usually rather numerous, generally placed singly in the angles between the plates of the basal radial areas, and sometimes on the central part of the disk, but not on the triangular interradial areas, where the plates are angular and closely in contact. The pedicellariæ when present are small, elevated, usually with two spatulate blades, higher than broad, and often set in special pits of corresponding shape. They may occur on any or all the kinds of plates, either above or below, or on both sides.

The adambulacral spinules are numerous and crowded, and grade into the actinal granulation; the furrow-series form a simple row, usually not much longer than those of the next series and not separated from them by a wide space. Distally some of the spines of the second series usually become much longer than the rest.

In the following table we give an arrangement of most of the figured species of *Tosia*, in sections and sub-sections.

Section A.—Typical. Distribution Indo-Pacific and Australian.

More or less of the marginal and abactinal plates are naked in the center, margined by one or two rows of granules. Adambulacral plates narrow, each with few spinules, usually only two or three in the furrow-series.

Pedicellariæ absent or not recorded in most species. Only one or two of the distal, dorsal, marginal plates are usually in contact medially.

b.—The actinal as well as abactinal and marginal plates are usually naked centrally.

T. australis Gray, Synop., p. 11, pl. 16, fig. 1. West Australia.

T. rubra Gray, Synop., p. 11, pl. 16, fig. 3. Australia.

T. tuberculatis Gray, Synop., p. 11, pl. 16, fig. 4. Australia.

T. magnifica (M. & Tr.), Ast., p. 53, pl. iv, figs. 1, *a*, *b*, 1842. Tasmania.

T. astrologorum M. & Tr., Ast., p. 54, Australia. A variety has pedicellariæ (*t.* Perrier).

bb.—The actinal plates are usually entirely covered with granules.

T. aurata Gray, Synop., p. 11, pl. 16, fig. 2 (= *Astrogonium australis* M. & Tr., *non* Gray, t. Perrier). Australia.

Pedicellariæ size of granules on abactinal plates.

T. grandis Gray, Synop., p. 11, pl. 3, fig. 1. West Australia.

T. tuberculata (Gray). Port Natal.

Section B. *Plinthaster.*—Pedicellariæ with narrow blades are present, of small size, about equal to the granules, or but little larger. Adambulacral plates are wider, about as large as the actinal plates, and bear many crowded spinules; usually four to six in the furrow series. Marginal and abactinal plates usually naked in the middle and often areolated. Three to five of the dorsal marginal plates are usually in contact medially. Atlantic.

T. Perrieri (Sladen) = *P. Perrieri* Perrier, 1894, p. 391, pl. 25, figs. 1*a*, 1*b*.

Off Morocco, 930 to 1590 meters.

Pedicellariæ occur on the abactinal and on both series of marginal plates. They are set in special bilobed pits. Upper marginal and abactinal plates are granulated only around the edges.

T. compta Ver. West Indies, 683 fathoms.

T. nitida Ver. West Indies, 335 fathoms.

Section C. *Ceramaster.*—All the plates, above and below, are usually granulated nearly or quite all over, unless rubbed; in some species the marginal plates may often have a small, naked, central area. Adambulacral plates with four to six furrow spines. Atlantic.

c.—Pedicellariæ absent or not recorded. Only one or two dorsal marginal plates are usually in contact medially.

T. granularis (Retz.). Arctic Ocean and both coasts of the North Atlantic, 20 to 750 fathoms.

The variety *Deplasi* Per. (1894, p. 401) has some of the marginal plates naked in the middle; the same occurs in some of our examples.

T. simplex Ver., 1895, p. 135. Off Martha's Vineyard, 640 fathoms.

The type of this species has a small naked spot in the middle of the marginal plates, above and below.

T. eximia Ver., 1894, p. 264. Off Nova Scotia, 80–122 fathoms.

T. Greenei (Bell, 1889); 1892, p. 74, fig. Off Ireland, 1000 fathoms.

T. placenta (M. & Tr.). Mediterranean, 40–50 fathoms.

T. mirabilis (Per.). Mediterranean.

T. mammillata (M. & Tr.). Locality unknown. Pedicellariæ absent on type (t. Perrier).

cc.—Pedicellariæ are present; their blades are higher than broad, usually spatulate or spoon-shaped. Only two to three pairs of dorsal marginal plates are in contact medially.

T. Vincenti (Per.), 1894, p. 396, pl. 26, fig. 2. East Atlantic, 946 to 1105 meters.

In this species there is a regular row of spatulate pedicellariæ on the row of plates next the adambulacral series.

T. hæsitans (Per.), 1894, p. 397, pl. 23, fig. 7, pl. 25, fig. 2. East Atlantic, 2210 meters.

Pedicellariæ small, numerous; they occur on the actinal, adambulacral, abactinal, and on both series of marginal plates. In the type some of the marginal plates are naked in the middle, perhaps accidentally rubbed. Three of the dorsal marginal plates are in contact medially.

T. Grenadensis (Per.), 1881, 1884, p. 232, pl. viii, fig. 2. West Indies, 176 fathoms. Pedicellariæ few, small, abactinal.

T. Gosselini (Per.), 1894, p. 399, pl. 26, fig. 4.

East Atlantic, 946 to 1440 meters.

Small spatulate pedicellariæ, with special pits, occur on the abactinal and both series of marginal plates.

T. pulvinus (Alcock, 1893), India, 1200 fathoms.

Tosia granularis (Retzius).

Asterias granularis Retzius, K. Vet. Akad. Nya. Handl., vol. iv, p. 238, 1783. Abilg., in Zool. Dan., fas. 3, p. 19, pl. xcii, 1788. Bruzelius, Diss. Sys. Ast., p. 10, 1805.

Astrogonium granulare Müller and Trosch., Syst. Asteriden, p. 57, 1842. Gray, Synop., p. 10, pl. 1, fig. 4, 1866. Verrill, Expl. by the Albatross in 1883, p. 542, pl. 18, figs. 48, 48*a*, 1885.

Goniaster granularis Lütken, Vidensk. Medd. nat. Foren., p. 146, 1865.

Pentagonaster granularis Perrier, Revis. Stell. du Mus., p. 224, 1876. Sladen, Voy. Challenger, vol. xxx, p. 268, 1889. Bell, Catal. British Echinod. in British Museum, p. 73, pl. x, figs. 4, 5, 6, 1892. Verrill, Distrib. of Echinod., Amer. Journ. Sci., vol. xlix, p. 135, 1895. Danielssen and Koren, Asteroidea, Norske Nordhavs-Expd. Zoöl., xi, p. 58, 1884.

Pentagonaster balteatus Sladen, Proc. Royal Irish Acad., i, p. 688, pl. xxv, 1891 (t. Bell).

Pentagonaster concinnus Sladen, op. cit., i, p. 690, pl. xxvi, 1891 (t. Bell).

A large specimen, from off Halifax, N. S., has the following characters:

The inner adambulacral spinules form a simple marginal row, with three or four spines on each plate, of which the proximal is smaller

and sets farther back, so as to be partly overlapped by the distal one of the preceding plate; the others are rather short, stout, blunt, scarcely tapered, about as long as the breadth of the adambulacral plates. Outside the furrow-series, each plate bears an actinal group of about seven to eleven short, stout, polygonal spinules or granules, one of which occupies the center, and the others surround it; those on the side next the furrow-series are much larger and somewhat longer than the rest. Oral spinules numerous, short, stout, polygonal, seven or eight on the border of the dentary plate, and a median or sutural group consisting of a row of six or eight on each plate, with two shorter intermediate or central rows of three or four smaller ones.

The actinal interradial plates are crowded, polygonal and closely covered with small polygonal granule-like spinules with rounded tips, about thirty on the larger plates, their size decreasing toward the marginal plates, where they are very small.

The marginal plates, above and below, are closely covered with similar but smaller granules. The plates of the upper surface are hexagonal on the radial areas of the bases of the rays, and are mostly transversely elongated, and surrounded by six papular pores, corresponding to the angles. In the interradial areas they are transversely rhombic, often with the acute angles truncated, where pores intervene. All are closely covered with small angular granules.

Madreporic plate small, with conspicuously convoluted, deep grooves and high ridges. It is nearer to the center than to the margin.

Taken on the American Coast, by the "Albatross," at several stations between N. lat. 44° 28′ 30″ and 41° 47′. Also taken by the Gloucester fishermen on the Banks off Nova Scotia. Occurs off the coasts of Norway and Great Britain.

Bathymetrical range, 50 to 471 fath. on the American coast. Rarely taken below 150 fathoms.

Tosia (Plinthaster) compta Ver., sp. nov.

PLATE XXVII. FIGURE 2.

Pentagonal with regularly incurved margins and short, tapering subacute rays. Radii as 13 : 8.

Marginal spines large, mostly nearly square, slightly convex, the upper and lower ones nearly corresponding along the margins of the disk, but alternating on the distal part of the rays. There are usually, in the type, 16 upper and 18 lower plates on each side of

the body, but on one margin there are two ventral plates corresponding to one of the upper dorsals nearest the median line, so that there appears to be an odd, lower, interradial plate on this side.

The dorsal marginal plates are smooth, microscopically strigillate, and naked except for a single row of small, round marginal granules and a central irregular cluster of large, well spaced, round granules, each implanted in a pit and easily detached. They are lacking on the small distal plates. Three or four of the distal plates are in contact medially. The apical plate is of moderate size, wedge-shaped proximally and prominent at the tip.

The ventral marginal plates have most of the surface covered with implanted round granules, like those of the upper ones, and distinctly larger than those of the marginal row.

The abactinal plates are flat, even, closely crowded, regularly arranged, and mostly of about the same size, though the median radial rows are easily distinguished. They are mostly rounded or hexagonal with rounded angles. They are covered with small hemispherical bosses, but are not granulated, having only a single row of minute grains around the edges. A group of these grains, of somewhat larger size, surrounds each papular pore. The latter are few and small, but easily visible; they are confined to the basal radial areas. The madreporite is small, convex, prominent, with fine gyri.

The proximal adambulacral plates bear each a strait, regular row of five or six short, blunt, prismatic spinules in the furrow-series. The actinal side bears a second row of about four stouter conical spinules, of about the same diameter, but larger than the actinal granules; the outer margin bears four to six granules, like those of the actinal plates. Distally the plates have an angular inner edge, with fewer and more slender spinules in an oblique row, while one or two of those in the actinal row become much longer and larger.

The actinal plates are large, mostly rhombic, well defined, and covered with rather coarse, somewhat conical granules, which are not closely crowded.

Pedicellariæ, about like the granules in size, with narrow oblong blades, occur very sparingly on the adambulacral and some of the actinal plates. The dentary plates are large, covered with spaced, conical granules, similar to those of the actinal plates, but larger; those near the apex become stouter and prismatic, like the apical teeth; there are 7 or 8 in the furrow-series, similar to the adambulacral spinules.

Greater radius, 44^{mm}; lesser, 27^{mm}.

Taken by the U. S. Fish Com. steamer Albatross in the West Indies, at station 2117, in 683 fathoms, and by the Blake, station xi, in 555 fathoms, 1880.

This species is very similar to *T. Perrieri* of the East Atlantic. Without a direct comparison of specimens it is impossible to say whether our form may not be merely a variety of the latter. However, the American form differs from the photographic figures of *T. Perrieri* in having larger marginal plates and in the details of the actinal surface. Moreover its pedicellariæ are much fewer and apparently are different in form.

Tosia (Plinthaster) nitida Ver., sp. nov.

Plate XXVII. Figures 1, 1*a*, 1*b*.

Pentagonal with regular incurved sides; 18 or 19 upper marginal plates on each side; 20 lower ones; 4 or 5 upper marginal plates are in contact medially.

Closely allied to the preceding species in form and most of the details of structure. It differs chiefly in the finer granulation and in having the abactinal plates more closely crowded and even, with less evident sutures between them and with the areolation of their surface much finer; the granules around their margins are also much smaller and lacking in many places, but a group of rather larger ones surrounds each of the very small, unequal papular pores, so that these appear quite distinctly over a limited basal radial area. They are lacking on the central part of the disk and on the large interradial areas.

The dorsal marginal plates are partially naked and smooth, but have a central group of well spaced, rounded, implanted granules, as in *T. compta*, but the granules are much smaller; the lower third of these plates is closely covered with small round granules, like those of the ventral plates. The adambulacral plates, on the proximal part of the groove, usually have five or six slender, compressed furrow spines, in a straight row; the actinal surface of each plate bears two rows of small, blunt, granule-like spinules, much like the granules of the actinal plates.

Pedicellariæ of small size, similar to the granules in appearance, occur sparingly on some of the distal adambulacral plates.

Greater radius, 27^{mm}; lesser, 15^{mm}.

Taken by the Albatross, in the West Indies, at station 2396, in 335 fathoms.

This species is so similar to the last, in most of its characters, that it might prove to be only a variety, if we had a large series for study. But although the type is not much more than half as large as that of *T. compta*, it has rather more marginal plates and more numerous adambulacral spinules and actinal granules. The reverse would usually occur in the young of this genus. Hence I am disposed to consider it a very closely related, but distinct, species.

Pyrenaster Ver., gen. nov. Type, *P. dentatus* Perrier.

Form flat, more or less pentagonal, or stellate with a broad disk. Rays tapered. Marginal plates rather large, those of the two series similar and generally paired; sometimes there is on one or more of the margins (rarely on all) an odd interradial plate,—but this seems to be more or less abnormal.

In the type the upper marginal plates are partially naked, and the abactinal plates usually have a small naked central area, surrounded by marginal granules, but this is not constant. The upper marginal plates in the type species are sometimes all separated by a row of abactinal plates; in other specimens of the same species two to five pairs are in contact medially. Actinal and inferior marginal plates granulated.

Pedicellariæ occur sparingly on the adambulacral plates; they are similar to the granules in size and height and have short chisel-shaped blades.

The dentary plates are large, triangular, with numerous prominent granules on the actinal surface, and with somewhat enlarged prismatic spinules on the oral margin.

Adambulacral plates large, squarish, with 4 to 7 furrow spinules in a regular marginal series; these are decidedly more elongated than the granules of the actinal surface and are separated from them by a naked space, as in *Mediaster*. Distally these plates become small, with the furrow end prominent and bearing a convex group of spinules, while one or two of the spinules of the second row, on the actinal side, become much longer and larger than the rest, as in *Tosia* and most of the allied genera.

The actinal plates are flat, rather large, polygonal, crowded and arranged in series parallel with the furrows.

The abactinal plates of the radial areas are rounded, convex and of two kinds, smaller, secondary, rounded plates being interpolated between and around the larger or primary plates. The smaller plates are, however, of the same form as the others, and are granu-

lated in the same way, but their presence gives an appearance of irregularity to the arrangement of the plates.

Papular pores are of moderate size and not very numerous; they are confined to the median radial areas. In young specimens these areas are small and well defined and the pores few. Each pore seems to be surrounded by a special group of granules.

This genus is distinguished from *Tosia* and *Pentagonaster* especially by the existence of smaller secondary, rounded plates between the primary abactinal plates, and also by the greater specialization of the furrow-series of adambulacral spines, for these do not grade into the actinal granulation, as they do in the genera referred to. In this respect this genus is more nearly like *Mediaster*, but the latter does not have the secondary abactinal plates, but has concealed, radiating connecting ossicles between the distinctly separated abactinal plates. *Peltaster* also has secondary abactinal ossicles, but they are different in character, and it also differs in having broad valvular pedicellariæ and graded adambulacral spinules.

Pyrenaster dentatus (Perrier) Ver.

Pentagonaster dentatus Perrier, Nouv. Arch. du Mus., vi, p. 242, pl. viii, fig. 3, 1884. Sladen, op. cit., pp. 265, 744, 1887.

Plate XXVII. Figures 3, 3*a*, 3*b*.

I have had an opportunity to examine Perrier's types of this species, in the Mus. of Comp. Zoölogy, and to compare them with those dredged by the "Albatross."

Among the latter there are both large and small specimens. They show remarkable variations in several respects.

Two large examples of the same size, Nos. 10,370 and 18,433, are of special interest. In the former, four or five distal pairs of dorsal marginal plates are in contact medially. In No. 18,433, which is closely similar in other respects, all the plates, or all but the last pair, are separated by abactinal plates. In this specimen, on one margin, two upper plates correspond to one lower, so that there is an odd median plate above. In some of the young specimens one or more odd, interradial marginal plates may occur both above and below.

This species was taken by the Blake Exp., in 41 to 1500 fathoms. By the Albatross it was dredged in several localities, in the West Indies and off the Carolina coasts, in 478 to 1639 fathoms.

Pyrenaster affinis (Perrier) Ver.

Pentagonaster affinis Perrier, Nouv. Arch. du Mus., p. 243, pl. viii, fig. 4. 1881. Sladen, op. cit., pp. 265, 744, 1889.

This is, perhaps, only a variety of the last. The coarser granulation and the differentiation of the granules around the margins of the abactinal plates, in the papular areas, are the special characters cited by Perrier. I have not seen the type.

Some of the younger examples, which I refer to this species on account of the last peculiarity, are not in other respects distinguishable from *dentatus*.

It was dredged by the "Blake" in 1131 and 1323 fathoms, in the West Indies, and by the Albatross.

Peltaster Ver., gen. nov. Type, *P. hebes* Verrill.

Form nearly pentagonal, with very short, obtuse rays. Marginal plates rather large, regular, decreasing in size distally, covered like all the other plates, above and below, with fine nearly uniform granules. Apical plate small.

Abactinal plates numerous, not large, closely crowded, of two kinds. The primary plates are mostly hexagonal. Between, and often surrounding them, are smaller roundish or irregular plates granulated like the larger ones, but with fewer granules. Papular pores small, numerous, arranged singly around the primary plates and occupying large radial areas.

Pedicellariæ, in the type, large, bivalve, sessile, with broad, lamelliform jaws, as wide as half the diameter of a plate. They occur mostly on the actinal plates next the adambulacral series. In *P. planus* none have been observed, but only one specimen is known. Adambulacral plates large, with several series of spinules, which are short, crowded, prismatic and grade into the granulation of adjacent plates. The furrow-series form regular rows of four to six on each plate; they are smaller and not longer than those of the next series, and there is no naked space between the series.

Distally one or two of those in the second series gradually change to much longer and larger blunt or conical spines. Dentary plates not prominent, covered with numerous blunt prismatic spinules, like those of the adambulacral plates, but rather coarser.

Actinal plates numerous, squarish or rhombic, closely crowded, the outlines obscured by their close, uniform granulation. They run in series parallel with the adambulacral furrows.

This genus is separated from *Tosia* on account of the small, irregular, secondary plates or ossicles between the primary abactinal plates, and the large, broad bivalve pedicellariæ of the type.

The characters of the marginal plates, actinal plates, and of the adambulacral spinules are like those of *Tosia*, of the *granularis* group (section C).

The second species (*planus*), although, so far as known, without pedicellariæ, is placed in this genus because it agrees with the type in the characters of the skeleton.

Peltaster hebes Ver., sp. nov.

PLATE XXVIII. FIGURE 4.

Form broadly pentagonal, with very short rays and a rather thick, flat disk and large, slightly convex marginal plates, decidedly higher than long. Radii as 7:8. All the plates are closely and uniformly granulated, above and below, and many actinal plate shave, in the type, central, large, bivalve pedicellariæ with broad blades.

Upper marginal plates about 20 on each side of the body; lower ones about 24 in the type. Along the sides of the disk the upper and lower ones are pretty closely paired and nearly of the same size and shape, though the vertical sutures are not strictly coincident, except between the middle plates, owing to the slightly wider lower plates. In each series the plates are nearly twice as high as long, and this form holds good except for the last two upper and last four or five lower plates, which decrease in size and change form very rapidly, the last ones being very small. The apical plate is very small, obconic, not prominent.

The abactinal plates are closely crowded, and so closely granulated that the outlines are concealed, unless denuded. The primary plates are rounded or polygonal, with many rounded angles, and are surrounded, in the radial areas, by many smaller secondary plates, having the same form and granulation, but variable in size, and mostly less than half the diameter of the larger plates. All are closely covered with small round granules, the marginal series scarcely different from the rest. The larger plates may have 40 to 50 granules, of which 18 to 24 may form the marginal row.

The papular pores are very small and numerous, placed singly, and occupy wide radial areas.

The adambulacral plates bear a closely crowded group of graded spines on the actinal side; the furrow-series consists of five or six short, thick, blunt, prismatic or compressed spinules, in a nearly

straight row ; next, and close to these, there is a row of three or four larger, angular blunt spinules of the same height; these are followed by another row of three or four similar but small spines, in a slightly curved row; then there is a group of five or six, sometimes forming rows, on the outer part of this plate, of the same form and size as the actinal granules.

The actinal plates are numerous and even, closely crowded, mostly rhombic or squarish, covered with granules that become angular where most crowded.

Large valvular pedicellariæ occupy the center of many of the plates in the series next the adambulacral ; they are about as broad as half the diameter of the plate, or more.

The dentary plates are not prominent, but are covered with numerous prismatic granules and spinules, larger than those of the adambulacral plates.

The madreporic plate is large, round, with numerous fine gyri. The dorsal nephridial pore is surrounded with granules larger then those of the surrounding plates.

Greater radius, 56^{mm}; lesser, 50^{mm}.

Taken by the Albatross, in the West Indies, at station 2668, in 294 fathoms, gray sand.

Peltaster planus Verrill.

Pentagonaster planus Verrill, Distr. Echinod., Amer. Journ. Sci., xlix, p. 135, 1885.

Plate XXVIII. Figures 3, 3*a*.

Form pentagonal, with the sides only slightly incurved ; rays very short, triangular, and obtuse, with the tip turned up and terminated by a small, conical plate.

Marginal plates large, median ones nearly square, higher than long, the upper and lower nearly corresponding, fourteen in the dorsal series and sixteen in the ventral series, all uniformly covered with rather coarse, rounded granules, standing a little apart; the margins of the plates with a regular row of granules of about the same size. The three distal dorsal plates are in contact medially. Apical plate small, obovate.

Abactinal plates nearly flat, the primary ones rather large, rounded or hexagonal with rounded angles, with many small, rounded, unequal secondary ones interspersed ; all are uniformly covered with rather coarse, spaced granules, like those of the marginal plates, so that the whole of the upper surface has a remarkably uniform granular coat-

ing. The larger plates often bear fifty to seventy granules; the small intermediate plates frequently carry but nine to twelve, one or two being central. Actinal plates large, rhombic, uniformly covered with coarse, angular granules, distinctly larger than those of the marginal plates.

Adambulacral plates numerous and crowded, similar to the actinal plates, but slightly larger and longer; toward the ends of the rays the plates are smaller and one or two of the first actinal row of spinules become much larger and longer, round and blunt. Each plate usually bears three or four marginal spines in a simple row; outside of these there are usually nine to twelve thicker, obtuse, angular spines, forming four irregular longitudinal rows, the outer ones smallest and like the actinal granules.

Dentary plates not prominent, covered with numerous blunt, angular spinules, similar to the actinal spinules, but larger.

The papular pores are numerous, placed singly, and occupy large radial areas, extending nearly to the center of the disk.

No pedicellariæ could be found.

Greater radius of the type, 50^{mm}; lesser radius, 35^{mm}; thickness at margin, 8^{mm}.

N. lat. 39° 53′, off Martha's Vineyard, in 156 fathoms, one specimen (No. 13,362).

Litonotaster Ver., gen. nov. Type, *P. intermedius* Per.

Stellate, with a rather broad, flat, flexible disk and tapered rays, becoming slender distally. The dorsal integument is so thin that it is wrinkled in the dried specimens. Marginal plates unusually small for this family. The dorsal ones encroach but little on the upper surface of the disk; distally they become irregular near the tip of the rays, in the type; two to four pairs are in contact medially (a single oblong plate, equal to two or three of the usual distal plates, may replace the latter on some of the rays).

Abactinal plates polygonal, flat, thin, closely united, finely granulated, with two or more rows of granules around the edges, but with a small, central, round, naked area, in the type.

Papular pores rudimentary, few, small, obscure, not visible except when the plates are denuded; they occur only between the three central rows of plates, in a very circumscribed basal radial area.

Actinal plates granulated, rather large, angular, of various forms, not forming regular rows.

Adambulacral plates are large, as wide as the adjacent actinal plates or wider. Each one bears seven or eight small, compressed furrow spines, in a regular row; the spinules of the actinal side are very small, on the proximal plates, and form an irregular group on the outer half or else stand more or less in three or four rows; most of them are scarcely larger than granules; distally one or two of the second row become much larger conical spines.

A small elongated pedicellaria, with two, three, or four spatulate blades, occurs on the center of many of the adambulacral plates and on some of the actinal plates.

The dentary plates are large, separated by an open suture; each one bears an actinal triangular group of numerous small granules and a furrow-series of about ten or twelve small, prismatic, blunt spinules, those toward the apex becoming larger.

This genus is separated from its allies mainly on account of the few and minute papular pores and the very limited area on which they occur; the thin and small marginal plates; flexible dorsal surface of the disk; and large number of adambulacral spines.

The type is the only species determined. Mr. Alcock has recorded this species from the East Indies. Possibly this may indicate a second species of the genus.

Litonotaster intermedius (Perrier).

Pentagonaster intermedius Perrier, Etoiles de Mer., p. 243, pl. v, figs. 5, 6, 1884. Sladen, Voy. Chall., xxx, p. 746, 1889.

Plate XXVIII. Figures 5, 5*a*, 5*b*.

This species was taken by the Blake Expedition in the West Indies, in 1930 fathoms.

It was also taken by the Albatross at station 2379, in 1467 fathoms, yellow ooze (two examples, No. 18,424).

I have compared the type described by Perrier, from the Blake Expedition, now in the Museum of Comp. Zoöl., with those taken by the Albatross. They agree closely. The larger Albatross specimen has the radii 33^{mm} and 14^{mm}.

Eugoniaster, gen. nov. Type, *E. investigatoris* (Alcock).

Form broadly pentagonal, with short rays. Abactinal plates uniformly small and rounded, naked, except for a marginal series of granules; some of them bear broad, bivalve pedicellariæ. Papular pores numerous, placed singly, radial. Marginal plates mostly naked with a border of granules and also some in a central group.

Bivalve pedicellariæ, with wide blades, occur on some of them, as well as on the adambulacral and actinal plates.

Adambulacral plates are covered with actinal granules in longitudinal rows; there are six or more prismatic spinules in a regular furrow-series. Actinal plates are granulated and extend to near end of rays.

This genus is related to *Peltaster*, but differs in having the abactinal plates all small and similar, and also naked centrally, and in having the marginal plates mostly naked, except around the margin. The large bivalve pedicellariæ are similar in the two genera. The character of the pedicellariæ differentiates the genus from *Tosia* and its closer allies.

Eugoniaster investigatoris (Alcock).

Pentagonaster investigatoris Alcock, Ann. and Mag. Nat. Hist., xi, p. 88, 1893.

This large species has, on the abactinal surface, "uniformly small round tabular plates, which are distinctly isolated from one another and are fringed with a single row of flat squamous, membrane-clad granules flush with the general surface, but are otherwise naked, except that some of the plates (perhaps one-fourth) bear a very excentric or quite marginal, broadly bilobed pedicellaria."

The marginal plates are also bordered with squamous granules and bear bilobed pedicellariæ; some also have a central group of granules.

Bivalve pedicellariæ also occur on the adambulacral plates and broad ones on the actinal plates near the jaws.

Adambulacral plates bear crowded, graded actinal granules in two or three longitudinal rows, and a furrow-series of six or seven prism-shaped spinules.

Antheniaster, gen. nov. Type, *A. sarissa* (Alcock, sp.).

This genus resembles *Anthenoides* Per. in having a thin, finely granulous membrane over the abactinal surface of the plates, but it differs so much in other respects that it cannot properly be referred to the same genus. The pedicellariæ are papilliform or spoon-shaped; not large and bivalvular as in the latter.

It has two kinds of abactinal plates, which is not the case in *Anthenoides*. The larger plates are "stellate or somewhat polygonal," arranged in radial rows; the small secondary plates are "inlaid everywhere between the large plates." Papular pores exist on large radial areas. Marginal plates are large and partly granulated; the dorsal distal plates are in contact medially and mostly naked.

Pedicellariæ of a simple papilliform structure occur on some of the upper plates. The lower marginal plates have two or three spines in a horizontal row; one distally.

The adambulacral plates have a divergent or palmate-series of furrow spines and a larger spine on the outer actinal end; many have also a central pedicellaria with spoon-shaped blades.

The actinal plates are numerous, in chevrons, and extend to about the 13th or 14th adambulacral plates; they are covered with a granulose membrane, and some bear papilliform pedicellariæ. The dentary plates are very prominent and bear large granules actinally, but the oral spines are large. The ambulacral feet have a terminal sucker.

Antheniaster sarissa (Alcock).

Anthenoides sarissa Alcock, Ann. Mag. Nat. Hist., xi, p. 99, 1893.

Andaman Sea, 139 to 250 fathoms.

Subfamily **HIPPASTERIINÆ**, nov.

This group is established for those Goniasteridæ that have large elongated, divergent, and differentiated adambulacral spines, one or two larger ones situated on the central part of the plate. The dorsal and marginal plates are bordered or covered with large granules and often have one or more central tubercles or stout spines. Bivalve pedicellariæ, often of large size, are usually present. The abactinal plates are thick, closely joined, and polygonal or roundish.

Hippasteria Caribæa Ver., sp. nov.

Plate XXVIII. Figures 1, 1*a*.

Form stellate with a rather broad disk and tapered acute rays; disk convex. Radii about as 2 : 1.

Marginal plates regularly paired, those of the interradial margin nearly square; all are bordered with coarse rounded granules, and some granules are scattered on the central parts; in some cases these form a central cluster on the lower plates. Most of the upper plates are naked centrally, and rise into a low conical tubercle, often surmounted by a small, round, ovate, blunt spine or large granule. Many of the lower plates have a central large bivalve pedicellaria with low, broad blades; their breadth is about half the width of the plates.

The abactinal plates are rounded, with a marginal row of coarse round granules; the center is occupied, in most cases, by a broad, low, bivalve pedicellaria, nearly as wide as the plate. Each plate of the radial areas and of the center of the disk has five or six papular pores around it. The apical plate is irregularly ovate, with a pair of small apical spines.

The actinal plates are not numerous, much crowded, and closely united, so that their outlines are obscure. They have marginal granules and a large central pedicellaria, like those of the actinal plates, but rather larger.

The adambulacral plates are narrower; each has two, or sometimes three, flattened, blunt or spatulate, often crooked furrow spines; a larger clavate spine in the next row, standing on the center of the plate; and three to five much smaller, unequal, conical or clavate spinules in a group on the actinal end.

The oral spinules are numerous, crowded, and much compressed.

Greater radius, 17.5^{mm}; lesser, 8.5 to 9.5^{mm}.

Taken by the Albatross at station 2668, N. lat. 30° 58′ 30″, W. long. 79° 38′ 30″, in 268 fathoms, gray sand (No. 18,425, one young).

The discovery of this tropical species is of special interest, for the genus was previously represented by only two species; one (*H. phryggiana*) found in the boreal parts of the North Atlantic, on both coasts, extending on the American coast to Cape Cod in moderately deep water; the other (*H. magellanica*) from the region of Patagonia. The occurrence of the genus in the intermediate tropical region is, therefore, significant.

Cladaster Ver., gen. nov.

Stellate, with a broad, flat disk; interradial margins regularly incurved; rays tapered.

Marginal plates of both series rather large, not numerous, encroaching upon both sides of the disk, regularly paired, except distally, decreasing regularly in size; about four pairs of the dorsal ones are in contact medially. No odd interradial plates. Apical plate and those adjacent, small.

The marginal plates and all the actinal and abactinal plates are normally granulated, but in the type many of the marginal and abactinal plates have irregular, partially naked central patches, covered with small pits where granules have fallen off.

Abactinal plates all polygonal with rounded angles, rather large, not numerous; the median row of the rays is distinct, and bordered

on each side by a regular row of about the same size and form, arranged alternatingly.

Papular pores are arranged singly around and between the three central radial rows of plates, except distally, usually six to a plate, but are absent from the small interradial areas.

Actinal plates are few, rather large, angular, rather irregular and do not extend beyond the second pair of marginal plates, in the type ; they are covered with well spaced, coarse granules. Pedicellariæ with two elevated spatulate blades occur on the middle of some of the actinal plates.

Adambulacral plates bear relatively large and long, prominent, interlocking, spatulate or club-shaped spinules. Two of these, on each plate, belong to the furrow-series and are much flattened. Outside of these, there is a stouter median spine, of the same length, usually not much flattened, clavate or blunt at the tip; outside of this there are usually two smaller, conical spinules, on the actinal margin. The larger spines of the first actinal row do not increase in size distally, as in *Tosia*, etc., but gradually decrease.

The dentary plates are rather large, flat, and bear marginal and sutural rows of elevated, flattened or spatulate spines, like those of the furrow-series.

This genus seems to be more nearly allied to *Hippasteria* than to any other.

Cladaster rudis Ver., sp. nov.

Plate XXVIII. Figures 2, 2*a*, 2*b*, 2*c*.

Rays narrow distally with four dorsal marginal pairs of plates in contact medially ; these distal plates are small and not regularly paired. Radii about as 2 : 1; greater radius, 25^{mm}; lesser, 12^{mm}.

Dorsal marginal plates vary from 13 to 15 on different sides of the body. Ventral plates 15. Those of both series are similar in form and size, thick, somewhat convex, rectangular, higher than long on the interradial margins, and encroach considerably upon both sides of the disk ; they are separated by deep sutures. Four larger pairs form the margins of the disk; those on the rays become rapidly smaller and more square. Those of both series are sparsely covered with coarse, rounded, well-spaced granules, many of which have fallen off, leaving small, shallow, rounded pits on the central portions of some of the plates. The marginal granules are of the

same form, but rather smaller and more closely arranged. The granules are higher than broad with a rounded top.

Abactinal plates are covered with granules like those of the marginal plates. They are roundish and slightly convex, in contact by their angles, between which some of them are slightly notched or incurved, to make room for the papular pores.

The madreporic plate is rather small, with many fine gyri.

The granules of the actinal plates are well-spaced and rather larger and more conical than those of the upper side; they form a marginal series, mostly of six to ten, which are somewhat divergent, and surround one or two larger central ones, which are sometimes replaced by a central pedicellaria, having broadly spatulate blades, rather higher than the granules.

The two outer spinules or granules of the adambulacral plates are like those of the actinal plates; there is often a minute conical spinule on the proximal side of the larger central spine.

Taken by the Albatross, off Florida, at station 1415, N. lat. 30° 44′, in 440 fathoms, coarse sand, shells and foraminifera (No. 18,426, one example).

Subfamily **MEDIASTERINÆ**, nov.

This subfamily is proposed for those Goniasteridæ that agree very closely with the typical Goniasterinæ in the structure of the actinal side and marginal plates, but have paxilliform abactinal radial plates in the papular areas. These plates may be in the form of protopaxillæ or parapaxillæ, but are usually covered by close granules and not by spinules, but sometimes they are spinulose. They stand a little apart, when denuded, and may appear stellate at base, *Mediaster* and *Nymphaster* are the leading genera. In these there are bivalve pedicellariæ.

In *Mediaster*, and probably other genera, these plates are united by small dermal radiating ossicles that do not show distinctly at the surface (see pl. xxvi, figure 8). In *Nymphaster* there are no connecting ossicles, but the columnar plates have enlarged and six-lobed bases. Some of the forms placed here show strong affinities to some Pseudarchasterinæ.

Mediaster Stimpson.

Mediaster Stimpson, Journ. Boston Soc. Nat. Hist., vol. vi, p. 490, pl. 23, figs. 7–11, 1857.

Mediaster Sladen, Voy. Challenger, Zool., vol. xxx, pp. 263, 752, 1889.

Isaster Verrill, Proc. U. S. Nat. Mus., vol. xvii, p. 257, 1894.

The original description and figure of this genus and of the type species by Stimpson were incomplete and rather imperfect, so that the genus has not been well understood by most subsequent writers who have referred to it. I have, therefore, thought it desirable to redescribe and figure the type species at this time.

Form stellate, with a broad flat disk and moderately long tapered rays. Marginal plates well developed, not swollen, granulated, rather numerous, higher than broad, paired, upper and lower series nearly equal in size and number and with their sutures more or less closely corresponding vertically; oblique in the type. No odd interradial plate. Abactinal plates or parapaxillæ are regularly longitudinally arranged, of moderate size, somewhat elevated, mostly roundish, covered with a rosette of short, obtuse spinules or granules. When these are removed the plates on the central part of the disk and along the median region of the arms appear as roundish or oval convex bosses. They are connected together by five or six internal radiating ossicles, between which are the pores for the papulæ.* The papulæ may be single, or (in the type) clustered. Thus the plates appear to be stellate at the base, though they are not actually of that shape. The median row of abactinal plates extends to the apical plate of the rays in the type, but not in some of the other species. Some of the abactinal plates bear a central, broad, sessile, valvular pedicellaria, which, in the type species, is nearly as wide as the plate. They are sometimes lacking.

The adambulacral plates bear a regular marginal row of three to seven slender spinules, and usually two exterior longitudinal groups or rows of shorter spinules, which may be angular and obtuse, and toward the tips of the rays, some of them, in the type, become larger and longer, as in *Pentagonaster* of authors. Some of these spinules may be replaced by spinuliform or clavate, two or three-bladed pedicellariæ. The actinal disk-plates are angular, often rhombic, closely arranged in rows parallel with the ambulacral grooves, covered with a rosette of granules, the central granules often replaced by a wide valvular pedicellaria. The dentary plates are not very prominent;

* I have found these ossicles in *M. æqualis* and *M. Bairdii*. Other species have not been examined as to this feature.

each has an actinal row of larger spinules, similar to those of the oral margin.

This genus is closely allied to *Pentagonaster*, as limited by Sladen and some other recent writers. The principal differences consist in the somewhat more elevated and convex abactinal plates, especially in the papular areas, where they are more widely separated by the large papular pores and united by intervening small internal ossicles, which give them a stellate appearance. On other parts of the disk, as near the interradial margins, the plates are angular and closely joined in a mosaic, as in the former genus. The large valvular pedicellariæ are also, to some extent, characteristic, but the marginal, actinal, and dentary plates and their spinules are essentially the same in the two genera. The spinules on the adambulacral plates are, however, more definitely triseriate, and the furrow series is more differentiated in all the known species, though this is perhaps of no more than specific value.

The type inhabits the Pacific coast of North America, in rather shallow water. No other species seems to have been described until a second one, from deep water off our north-eastern coast, was described by me in 1882, under the name of *Isaster Bairdii*. Its close affinity to *Mediaster* was not recognized at that time, though I have referred it to that genus, for several years, in my MSS. lists and in the museum catalogues.

Mediaster æqualis Stimp.

Journ. Boston Soc. Nat. Hist., vol. vi, p. 490, pl. 23, figs. 7–11, 1857.

Plate XXIV. Figures 10, 11, 12.

Rays five, in length about equal to the diameter of disk, regularly tapered, slender at the tip. Radii nearly as 1 : 3. Marginal plates on each side of a ray 22, above and below, in a specimen having the greater radius 36^{mm}. The plates on the margin of the disk are higher than wide with the intervening sutures somewhat oblique. The lower marginal plates are similar in size and shape. All are closely covered with small rounded granules. Abactinal areas of the rays are wide at the base, where they may consist of seven or nine rows of plates, but they rapidly decrease to three rows, and only the median row reaches the apical plate. The papular areas are large, covering nearly the whole width of the proximal half of the rays, as well as most of the central disk. In these areas the plates are rounded or elliptical, convex, somewhat elevated, and separated by

intervening spaces, in which there are usually five or six groups of papular pores, the individual pores being small and unequal, two or three or more forming each group.

Each of the larger abactinal radial plates is covered with a rosette consisting of about five to seven central, and twelve to fourteen marginal, short, blunt or clavate, granule-like spinules, rather longer than broad. Some of the disk-plates are larger with more spinules. A large valvular pedicellaria often replaces the central group of spinules on some of the plates. These occupy nearly the whole breadth of the central area of the plate, and are narrowly oblong, not much elevated, with a nearly even and straight margin. Similar pedicellariæ, as well as some much narrower ones, occupy the central area of some of the actinal disk-plates.

The madreporic plate is small, sunken, with narrow, acute gyri. The central nephridial pore is small but distinct.

The actinal disk-plates are crowded and closely united; those next the adambulacral plates are squarish or rhombic and form regular rows, but those in the angles are smaller, irregular, and more rounded. All are covered with rosettes of granules, or short, obtuse, often prismatic spinules, rather larger and less regular than those of the upper side. A central valvular pedicellaria occurs on some of the plates, as stated above.

The adambulacral plates are squarish, not very large. Each bears a marginal row of three or four, small, oblong, more or less prismatic or compressed, blunt spinules, the middle one usually a little larger than the others. External to these are two sets of shorter spinules, about three in each series; these sometimes form two rows, but in other cases are in a rosette-like group; those next the inner or groove-series are longer than the others; one or more of these, especially distally, may be replaced by a spinuliform pedicellaria with two or three blades. On the distal part of the ray one or two of the spinules on the central part of these plates becomes considerably longer and larger than the rest. The oral spinules are similar to the adambulacral, but those at the tip of the oral plates are rather larger and more angular. The apical plates are rather small, prominent, somewhat obovate.

Radius of disk, 13^{mm}; of rays, 36^{mm}.

Off Wilmington, Cal., 27 fathoms, U. S. Nat. Mus.

Mediaster Bairdii Verrill.

Archaster Bairdii Verrill, Amer. Journal Sci., vol. xxiii, p. 139, 1882.
Isaster Bairdii Verrill, Proc. U. S. Nat. Mus., vol. xvii, p. 258, 1894. Amer. Journal Sci., vol. xlix, p. 136, 1895.
Mediaster stellatus Perrier, Mem. Soc. Zool. de France, iv, p. 268, 1891. Results des Campag. Scient., fas. xi, p. 46, 1896, pl. iv, figs. 1–1d.

Plate XXIV. Figures 1–9. Plate XXVI. Figures 8, 8*a*.

A comparison of this species with the type-species of Stimpson has convinced me that they are very closely allied and should be referred to the same genus, though the Atlantic species is often nearly or quite destitute of pedicellariæ. But when pedicellariæ do occur they have nearly the same valvular forms seen in those of *M. æqualis*, though they are narrower and more elevated.

Mediaster Agassizii, sp. nov.

Five-rayed; regularly stellate, with a large disk and rather long tapered rays. Radii nearly as 1 : 3. Interradial angles are broadly curved.

Marginal plates large, nearly square, slightly convex, but not swollen; 36 dorsal and 38 ventral ones in the type, on each of the five sides; the transverse sutures between those of the upper and lower series are narrow and shallow and usually do not coincide.

The upper plates are sparsely granulated centrally, having only a few rather distant, rounded granules; their margins are surrounded with a close row of angular granules, but these do not form distinct fascioles. Some of the upper marginal plates have also small valvular pedicellariæ.

The lower marginal plates are coarsely granulated over the whole surface, the granules being larger than those of the upper ones; most of them also have one to three or more, oblong, valvular pedicellariæ, larger than those of the upper plates.

The abactinal plates are regularly arranged in radial series, very unequal in size, mostly roundish in outline, naked in the middle, but with a marginal row of coarse angular granules.

Many of them have a central, large, oblong, valvular pedicellaria, sunken in a pit; on the larger plates the pedicellaria is about one-half the diameter of the plate, but on the smaller plates it often occupies nearly the entire breadth of the top. Some of the plates lack the pedicellaria and have a central granule in its place. The valves of these pedicellariæ are usually higher than broad, with the blade broadly spatulate distally.

The abactinal plates become suddenly reduced to three radial rows, about opposite the fourth or fifth pairs of marginal plates, and a little farther out only the median row remains; this disappears about opposite the ninth pair of plates, beyond which the nine distal pairs of marginal plates are in contact medially. The apical plate is rather small, subconical, prominent. The papular pores are small and scattered singly over large baso-radial areas.

The actinal interradial plates are angular and polygonal, rather large, closely crowded together, forming rows parallel with the ambulacra; they are covered with large, crowded, rounded granules; most of them have, also, a single, large, oblong or elliptical, valvular pedicellaria, usually occupying about one-half the width of the plate.

The adambulacral plates have each four or five, short, stout, blunt, angular or prismatic spines in the furrow-series, placed in a regular row; next to these, on the actinal surface, there is also a row of three similar, but shorter, compressed spinules; on the outer end there are one or two rows of smaller and shorter, thick spinules; a large valvular pedicellaria usually occupies the center of the plate, but when it is absent there is a central row of spinules, making four rows on the actinal surface.

The dentary plates are large; each one, of a pair, bears about five stout, blunt, prismatic or compressed spinules in the furrow series, and two rows of short, thick, obtuse spinules on the actinal surface, those next the mouth being largest; at the apex of the jaw there are two larger, thick, blunt, prismatic and compressed spines.

Lesser radius, 25^{mm}; greater radius, 75^{mm}. Taken by the Blake Expedition, in the West Indies.

This fine species appears to be closely allied to *M. pedicellaris*. It is referred to the genus *Mediaster* with some doubt, for the character of the abactinal skeletal plates could not be satisfactorily ascertained by an external study of the single alcoholic specimen.

Mediaster (?) pedicellaris Verrill.

Goniodiscus pedicellaris Perrier, Nouv. Arch. du Mus., vi, p. 245, pl. iv, fig. 3, 1884. Sladen, op. cit., p. 756, 1889.

The following notes were made upon one of the original types of Perrier, in the Museum of Comp. Zoölogy.

Radii as 7:19. Dorsal or abactinal plates, large, roundish, the summit convex when naked, but flat when covered with the spinules; the largest have about sixteen marginal, tapered, acute spinules, and one to five or more somewhat larger acute central ones. Intervening

papular pores large, single, about six around each plate, except that there are none between those plates in the middle radial rows ; a row on each outer border of the abactinal space extends nearly to the end of the rays, or to within about ten marginal plates of the end, and as far as the rows of lateral plates extend.

The median series of plates extends about four or five plates farther than the lateral, but ceases within four or five plates of the tip; from thence the marginal plates are in contact.

Upper marginal plates bevelled and covered with small, sharp, spaced spinules; the upper spinules are shorter than the lower ones, larger, stouter, acute, divergent ; those around the margins are similar and do not form regular fascioles.

Lower marginal plates large, roundish, with one or two marginal series of sharp, divergent, stout spinules, and a central larger one. Sometimes there are three to five central spinules on the dorsal plates and on the row of plates next to the adoral plates. Pedicellariæ small, narrow, elevated, spatulate in form and rather numerous on the dorsal side. Lesser radius, 18^{mm}; greater, 59^{mm}.

Station 295, Blake Exped., 180 fathoms. This species was also taken by the *Albatross* in the West Indies.

Mediaster arcuatus (Sladen).

Pentagonaster arcuatus Sladen, Voy. Chall., Zool., vol. xxx, p. 277, pl. xviii, figs. 5, 6 ; pl. lii, figs. 1, 2, 1889.

This species has a few small pedicellariæ on the abactinal plates, similar in size to the granules.

South of Yeddo, Japan, 345 fathoms.

Mediaster Japonicus (Sladen).

Pentagonaster Japonicus Sladen, op. cit., p. 272, pl. xlvi, figs. 1, 2 ; pl. xlix, figs. 1, 2, 1889.

This species has rather large, sessile, bivalve pedicellariæ with broad valves, on the adambulacral plates ; others of smaller size occur on many of the actinal plates. Some of the pedicellariæ have three valves.

South of Yeddo, Japan, with the last.

Mediaster Patagonicus (Sladen).

Pentagonaster Patagonicus Sladen, op. cit., p. 269, pl. xlvi, figs. 1, 2; pl. xlix, figs. 3, 4, 1889.

This species has rather small, sessile, somewhat elevated pedicellariæ, sparingly scattered on the abactinal and superior marginal plates; their blades are usually chisel-shaped or spatulate, and variable. Similar ones occur sparingly on the adambulacral plates. Larger ones, with broader valves, occur on the actinal plates; some of them have three or four blades. The dorsal marginal plates and some of the ventral ones have a small central naked area.

Near Atlantic entrance to Straits of Magellan, 55 fathoms; off entrance to Smyth Channel, 245 fathoms.

The *Mediaster roseus* (Alcock, 1893, p. 98), from India, 740 fathoms, is not a true *Mediaster*. It appears to belong to *Pseudarchaster* and resembles *P. granuliferus* V.

Nymphaster Sladen.

Nymphaster Sladen, Narrative Chall. Exp., i, p. 612, 1885. Voy. Chall., vol. xxx, p. 294, 1889.

Pentagonaster (*pars*) Perrier, Etoiles de Mer, p. 233, 1884.

Dorigona Perrier, Exp. Trav. et Talism., p. 365, 1894 (not of Gray, 1866, p. 7, nor of Perrier, 1876, p. 44.)

Plate XXVI. Figure 7.

This genus is closely allied to *Mediaster*. It differs chiefly in having, in the typical species, the dorsal marginal plates in contact medially for the greater part of the length of the rays. The character of the pedicellariæ, adambulacral plates and spines, jaws, and marginal plates is essentially the same in both, though the pedicellariæ are usually higher and spatulate in this genus.

The abactinal radial paxillæ, in the papular areas, differ in structure from those of *Mediaster*. In *N. ternalis* these plates, when separated, have no basal connecting ossicles, so characteristic of the latter. They are short, thick, columnar, with the basal portion somewhat swollen and slightly six-lobed; they articulate by means of the lobes, while the papular pores are situated in the spaces corresponding to the emarginations. The lobes are so slight that they can hardly be called stellate. The stellate appearance, as seen from the exterior, is due to the radial connecting bands of soft tissues between the pores. These plates are less stellate at base than those of *Pseudarchaster*, and rather more so than those of *Plutonaster*.

The name *Dorigona*, used for this genus by Perrier, is untenable. The type of Gray (1866) was *D. Reevesii* = *Ogmaster capella*, and the only other species mentioned by him was *longimana* (Mobius). The genus, as understood by Gray, was synonymous with *Ogmaster* (Von Mart.) of earlier date, and therefore should be dropped. If it were desirable to retain it at all, it should have been restricted to *D. longimana*. For the latter, Sladen, 1889, established the genus *Iconaster*, thus excluding *Dorigona* from the system.

Perrier, 1876, p. 44, used *Dorigona* for a section or a subgenus of *Pentagonaster*, and included in it *P. longimanus* and *P. capella* (as *Mulleri*), thus closely following Gray. But in his later work (1894), he has restricted it to *Nymphaster* Sladen, a group totally unknown to Gray and to Perrier, himself, in 1876.

This total transposition of the name is not justifiable. Perrier, himself, has disapproved of such a course in other cases of the same kind.

Seven species of *Nymphaster* have been described from the Atlantic and others from the Indo-Pacific. Probably the number of Atlantic species may be hereafter reduced when direct comparisons of the types shall have been made. I have studied only the three American species, from the types of Perrier and a good series dredged by the Albatross.

Atlantic species of Nymphaster.

Nymphaster ternalis (Per.).

Pentagonaster ternalis Per., 1881, p. 20; 1884, p. 233, pl. x, fig. 1.
Nymphaster (?) *ternalis* Sla., 1889, p. 752.
Dorigona ternalis Per., 1894, p. 371.

Plate XXVI. Figure 7.

West Indies, in 416 and 734 fathoms (Blake Exped.). Also dredged by the Albatross, at nine stations in the Gulf of Mexico and West Indies in 196 to 1181 fathoms, muddy bottoms, and at two stations off Brazil.

Nymphaster subspinosus (Per.).

Pentagonaster subspinosus Per., 1881, p. 21; 1884, p. 234, pl. vi, fig. 1.
Nymphaster (?) *subspinosus* Sla., 1889, p. 752.
Dorigona subspinosa Per., 1874, p. 375.

West Indies, 163 to 209 fathoms (Blake Exped.). Also dredged by the Albatross at two stations in the West Indies, in 338 to 388 fathoms, coral sand and gray sand.

Nymphaster arenatus (Per.).

Pentagonaster arenatas Per., 1881, p. 21; 1884, p. 236, pl. vii, figs. 3, 4.
Nymphaster (?) *arenatas* Sla., 1889, p. 752.
Dorigona arenata Per., 1894, p. 379, pl. xxii, fig. 6, pl. xxiv, figs. 5, 6.

Found on both sides of the Atlantic. It was taken by the Blake in the West Indies, in 164 to 874 fathoms, and by the Travailleur and Talisman, at many localities, in 157 to 1635 meters. It was also dredged in the West Indies by the Albatross.

Nymphaster Jacqueti (Per.).

Dorigona Jacqueti Per., 1894, p. 383, pl. xxi, fig. 4, pl. xxii, fig. 5.
Dorigona prehensilis Per., 1885; 1894, pp. 32, 33.
Nymphaster (?) *prehensilis* Sladen, 1889, p. 752.

East Atlantic, from N. lat. 44° 5′ to 28° 35′, in 540 to 1238 meters.

Perrier does not explain why he has changed the name of this species from *prehensilis* to *Jacqueti*, except that he states (1894, p. 426) that the former is a "variety" of the latter. If no other reason exists, the earlier name should be retained.

Nymphaster protentus Sladen.

Voy. Chall., xxx, p. 303, pl. l, figs. 3, 4, pl. liii, figs. 9, 10, 1889.
Off Canary Islands, in 1525 fathoms.

Nymphaster albidus Sladen.

Voy. Chall., xxx, p. 306, pl. li, figs. 1, 2, pl. liii, figs. 5, 6, 1889.
Off Cape Verde Islands.

Nymphaster basilicus Sladen.

Voy. Chall., xxx, p. 308, pl. lvii, figs. 8, 9, 1889.
Off Brazil, 1200 fathoms.

Two Indo-Pacific species, described by Sladen, differ from all the others in having a single median row of abactinal radial plates between the dorsal marginal ones, nearly or quite to the tip of the rays. In this group the pedicellariæ are high and spatulate, as in *Goniaster*, and the adambulacral spines are in very regular parallel rows. This group may, therefore, well deserve a distinct generic or subgeneric name, and I would suggest *Nereidaster*, with *N. symbolicus* as the type. The two species are as follows :—

Nereidaster symbolicus (Sla.), op. cit., p. 297, pl. 1, figs. 1, 2, pl. liii, figs. 7, 8, 1889.

East Indies and Philippines, 28 to 140 fathoms.

Nereidaster bipunctus (Sla.), op. cit., p. 301, pl. lii, figs. 3, 4, pl. liii, figs. 11, 12, 1889.

Off Admiralty I., 150 fathoms.

Subfamily. **PSEUDARCHASTERINÆ** Sla. (emended).

Pseudarchasterinæ Sladen, Voy. Chall., xxx, p. 109, 1889.
Astrogoniinæ (*pars*) Per., Exp. Trav. et Talism., pp. 337, 338, 1894.

This subfamily is remarkable for combining, in various ways, the structures that are generally characteristic and distinctive of Goniasteridæ and Plutonasteridæ. The intermediate character of the group is so marked that Perrier and Sladen have differed as to its place. Perrier placed it in his Pentagonasteridæ, while Sladen placed it in his Archasteridæ. In fact, its affinities appear to be nearly evenly balanced between the two groups. True pedicellariæ, which might throw light on the subject, are generally absent from all the known species of the typical genera.

The abactinal radial plates are arranged in radial rows, the medium ones larger. They are paxilliform, more or less columnar, with round or elliptical convex tops, and with an enlarged six-lobed or stellate basal portion, the projecting lobes articulating and leaving spaces between them for the papular pores, which occupy large radial areas. About six are arranged singly around each of the plates.

Marginal plates are thick, moderately large and paired ; they have deep fasciolated sutural grooves between them. The dorsal plates are rarely in contact medially, unless close to the tip of the rays. They are covered with close granules or small, crowded, appressed spinules, and the lower ones often have several larger central spines of the same character, but in some species the plates are all evenly granulated.

The adambulacral plates are broad, and usually angular or convex on the furrow margin, so that the furrow is constricted opposite each pair, especially distally. The furrow spines are usually in a curved or divergent series ; those of the actinal side may be in longitudinal rows or clustered.

The actinal plates are often numerous, angular, arranged in chevrons, with the rows parallel to the ambulacral furrows. More or less

of those in the rows next the adambulacral plates have their transverse edges bordered by specialized spinules, forming with those of the plates opposed to them, special fascioles (*pedicellaires fasciolaires* of Perrier). But they are not real pedicellariæ.

True papilliform pedicellariæ occur very rarely on the actinal and marginal plates in *Paragonaster*.

The jaws are rather large and prominent and bear numerous elongated spinules, both on the actinal surface and the margin. At the oval apex of the jaw there is usually a larger odd median spine, but this is not constantly present in all species, and in certain species it is generally, if not always, lacking. Some specimens may have the odd spine on some of the jaws and lack it on others, so that it cannot be considered of much morphological importance, though its presence is a useful indication of the affinities of certain doubtful species.

The ambulacral feet have well formed suckers, as in *Nymphaster* and *Mediaster*.

In the general appearance of the abactinal and marginal plates and the granulation of the dorsal surface this group agrees essentially with *Mediaster* and allied genera. It differs from that group mainly in the more prominent margins of the adambulacral plates, the lack of bivalve pedicellariæ, and the more divergent groups of furrow-spinules, together with the usually spinulose covering of the actinal and inferior marginal plates; but this last character is not constant.

The singular actinal fascioles are characteristic of many species, but are not constant. The same is true of the odd apical spine of the jaws.

If true bivalve pedicellariæ were present we should not hesitate to combine the group with *Mediaster* and *Nymphaster* in one subfamily.

On the other hand, the adambulacral plates and spines, the jaws, and the form and structure of the dorsal paxillæ are very much like those of *Plutonaster* and allied genera, though the latter does not have the regular serial arrangement of the radial abactinal plates. Nor is there in this group any distinct arrangement of the actinal plates in rows running from the adambulacral plates to the marginals, as in *Plutonaster* and allied genera.

The actinal plates have nearly the same form and are imbricated in the same way as in *Mediaster*. The adambulacral plates next the dentary plates are somewhat oblique and slightly modified, but much less so than in *Plutonaster*, and more so than in *Tosia* and *Mediaster*.

The jaws are also intermediate, in respect to size, form, and amount of elevation of the actinal ridges, between *Mediaster* and *Plutonaster*. The enlarged stellate bases of the abactinal radial paxillæ may be considered as a farther development of the slightly enlarged and lobate bases at the columnar paxillæ of *Plutonaster*. There are no separate, internal, radiating connecting ossicles between the plates, such as exist in *Mediaster*. At least, I have not found them in anatomical preparations of *Pseudarchaster intermedius* and *Paragonaster formosus*, both of which have enlarged six-lobed bases on the paxilliform plates.

But in *Nymphaster* (*ternalis*) the connecting ossicles are also lacking, and the plates are short-columnar, with the bases only slightly enlarged, thick, and but slightly six-lobed, the lobes being rounded and often indistinct. The same is true of the corresponding ossicles of *Rosaster*.

Considering all these points, the affinities of the group seem to me rather more with *Nymphaster* and *Mediaster* than with any other genera. This is also the view taken by Perrier (1894).

Pseudarchaster Sladen. Type, *P. discus* Sladen.

Pseudarchaster Sladen, 1885, p. 617. Voy. Chall., xxx, p. 109, 1889.
Astrogonium (*pars*) Perrier, Exp. Trav. et Talism., p. 338, 1894 (not of M. and Troschel, nor of Gray).

The principal characters of this genus have been mentioned in the above description of the subfamily.

The adambulacral plates have a divergent or palmate series of furrow spines and a group or radiant cluster of actinal spines. The actinal plates are generally closely covered with small appressed spinules, often somewhat squamiform, rarely elongated, but frequently a few larger spinules exist among the smaller ones. Lower marginal plates are usually spinulated like the actinals, rarely granulous, often with one or more central rows of larger appressed spinules.

Specialized fascioles usually (but not always) exist between more or less of the larger actinal plates, especially toward the jaws. The ambulacral feet have well formed suckers.

The abactinal plates and upper marginals are usually closely granulated. More than one series of abactinal plates usually extend nearly to the ends of the rays.

Perrier united *Aphroditaster* with this genus, but the type seems to me sufficiently distinct. However, the presence or absence of the

specialized actinal fascioles cannot be made a character by which to distinguish them, for they may be present or absent in the same species (e. g. *intermedius*). Their presence seems to be the normal condition.

Six species are known to me from off the American coast. Several other species have been described from the East Atlantic.

Pseudarchaster intermedius Sladen.

Pseudarchaster intermedius Sladen, Voyage of the Challenger, vol. xxx, p. 115, pl. 19, figs. 3, 4; pl. 42, figs. 5, 6, 1889. Verrill, Proc. Nat. Mus., vol. xvii, p. 249, 1894. Amer. Jour. Sci., xlix, p. 131, 1895.

Archaster Parelii (*pars*) Verrill, Amer. Journ. Sci., vol. vii, p. 500, 1874 (not of Düben and Koren); vol. xxiii, p. 140, 1882; Rep. U. S. Com'r Fish and Fisheries, vol. xi, p. 543, 1884.

Plate XXX. Figures 1, 1*a*, 1*b*.

This is the most common species off the eastern coast of the United States and Canada.

It was taken at about 33 stations by the Albatross and Fishhawk, 1880 to 1887, in 85 to 1608 fathoms, from N. lat. 44° 26′ to 37° 59′ 30″. It has also been brought from the fishing banks, off Nova Scotia, by the Gloucester fishermen.

The variety (*insignis*) named and described by me in 1895 (p. 132), is probably only the fully adult form of this species. The largest example has the larger radius, 75^{mm}; the lesser, 23^{mm}. It lacks distinct actinal fascioles. These exist, however, in variable numbers, on other similar specimens, of somewhat smaller size, as well as on quite young examples. Their presence does not depend upon age, for they may be absent or present in specimens of equal size. Most specimens have the odd apical oral spine somewhat larger and longer than those adjacent. The genital pores are opposite and close to the first pair of dorsal marginal plates.

Pseudarchaster fallax Perrier.

Astrogonium fallax Per., 1885. Exp. Trav. et Talism., p. 347, pl. xiii, fig. 4, pl. xxv, fig. 4, 1894.

Archaster Parelii (*pars*) Verrill, Rep. U. S. Comm. Fish and Fisheries for 1883, vol. xi, p. 543, pl. xiii, fig. 37, 1885.

Plate XXX. Figures 2, 2*a*.

This was formerly considered by me a variety of the preceding with narrow dorsal radial areas.

More recently I have compared our specimens with one of the types of *P. fallax* Per., in the Mus. of Comp. Zoology. They agree with the latter in all respects.

The species can be distinguished by the larger and more massive marginal plates, which encroach farther upon the dorsal surface, and by the very narrow abactinal areas on the rays. The granulation of the actinal plates is also closer and the adambulacral spines are shorter than in *P. intermedius*, but the two are very closely related. There is an odd apical spine on the jaws. Actinal fascioles are generally present.

Pseudarchaster (?) hispidus Ver., sp. nov.

Plate XXX. Figure 5.

Pentagonal with moderately long rays. Radii as 1 : 2.

About twenty-five marginal plates, above and below; these are rectangular, broader than long, not oblique. The upper ones extend only a short distance on the dorsal surface, and are only a little convex. They are covered with numerous very small, slender spinules; those on the middle are erect, but those on the margins form fascioles of very slender spinules.

Inferior marginal plates extend far within the margin; they are spinulated much like the upper ones, but the spinules are larger, longer, tapered, acute, arranged obliquely and divergently in four or five rows, not counting the marginal fascioles; usually none of the median ones are distinctly larger than the rest, but sometimes, on a few plates, one or two of the distal ones are somewhat larger and longer.

Abactinal paxillæ are relatively large, rounded, and nearly uniform in size. There is a somewhat distinct median row on the rays. About six rows occur opposite the third pair of marginal plates; they are reduced to three rows near to the end of the rays, and to one median row between the last three plates. They are uniformly covered with small, sharp, elongated, divergent spinules, often thirty or more in a group. Of these, twenty or more may be marginal and a little smaller than the others, the adjacent ones interlocking so as to conceal the papulæ. These appear to be small and few. The plates are round, elevated, convex or somewhat clavate, well separated.

Interradial actinal regions are of moderate size, triangular, with the outer plates extending out to about the seventh pair of interambulacral plates. They are in rows parallel with the adambulacrals and not separated by radiating grooves. They are rather large, roundish, covered with rather long, divergent, acute spinules, often nine to twelve on the larger ones.

Jaws a little prominent, bearing a large number of slender marginal spines and very numerous similar ventral ones, in about two crowded rows on each half. The apical spines are only a little larger than the marginal ones.

Adambulacral plates on the middle of the rays bear about four or five relatively very long and very slender, terete spinules on the convex marginal edge; one to three on the actinal surface, of similar size and form, and four or five divergent ones on the outer margin, that are shorter, but of the same form. No pedicellariæ were seen. The abactinal and ventral plates and paxillæ are much larger and fewer than in any species of *Plutonaster* or *Dytaster*, of similar size, and the appearance is decidedly hispid under a lens, owing to the elongated and acute spinules of the whole surface. Greater radius, 12^{mm}; lesser, 6^{mm}.

Taken by the Blake Expedition in the West Indies, in 600 fathoms, and by the U. S. Fish Commission Steamer *Albatross*.

The specimens of this species that I have examined are doubtless immature, but they differ decidedly from the young of the other known American species. It is not a typical *Pseudarchaster*.

The specimen from the Blake Expedition was mixed with specimens labelled as *Plutonaster intermedius* by Perrier.

Pseudarchaster granuliferus Ver., sp. nov.

Plate XXX. Figures 6, 6*a*.

Form stellate with a broad disk and deeply emarginate sides, the rays wide at base and tapering rapidly to acute tips.

Radii as 1:2.20. Greater radius, 22^{mm}; lesser, 10^{mm}.

The marginal plates are large and thick, encroaching considerably on both sides of the disk, producing a rather thick rounded margin. The upper ones are closely covered with polygonal granules; the lower ones are closely covered with small, uniform, closely appressed, ovate, subsquamiform granules or granule-like spinules, without any larger median ones.

The abactinal plates are small, rounded, elevated, and covered with a polygonal group of prismatic granules, about five to eight forming the central cluster. Papular pores are regularly arranged, and placed singly between the basal radial plates. The madreporic plate is small and irregular.

Actinal plates are crowded and covered with spaced polygonal granules, without any spinules. On each area there are three to five special pectinate fascioles of small size, one of which is opposite

the dentary suture. The adambulacral plates have a curved, palmate, strongly projecting furrow-series of five or six unequal blunt spinules; the two or three median ones are larger and more slender, compressed ; the two distal ones are shorter, stouter, flattened or spatulate, but on the distal half of the rays they are all slender. The actinal side is covered with shorter, obtuse or clavate spinules, either clustered or in two or three irregular rows, but without any larger central spines.

The jaws are not prominent ; there is an odd apical spine on each jaw, distinctly larger and longer than the rest ; the furrow margin bears ten to twelve small obtuse spinelets, like those of the adambulacrals ; the distal ones are rather larger than the others. On the sutural margin there are about ten shorter blunt or clavate spinules, a little larger than the actinal granules ; another small intermediate row of similar ones covers the actinal surface.

Taken by the Albatross at station 2751, in —— fathoms. One example (No. 18,448*a*).

Pseudarchaster concinnus Verrill.

Pseudarchaster concinnus Verrill, Proc, U. S. Nat. Mus., vol. xvii, p. 250, 1894. Amer. Jour. Sci., xlix, p. 132, 1895.

Plate XXX. Figures 3, 3*a*, 3*b*.

Taken at 3 stations between N. lat. 41° 28′ 30″ and 41° 07′; in 1188 to 1791 fathoms.

In this species the genital pores are large and usually plainly visible, without preparation. They are situated far apart on the dorsal surface, about opposite the second pairs of dorsal marginal plates; they are separated by about nine radial rows of abactinal interradial plates ; about six plates intervene between the pore and the marginal plate.

The jaws often have an odd apical oral spine, only a little longer and larger than those adjacent. In other cases no such spine is found, the apical spines being all paired. This variation may occur on the different jaws of the same specimen.

In this species there is less distinction between the smaller and larger spines on the lower marginal plates, there being many intermediate in size, and the largest not very large, in three or four irregular rows. The adambulacral and dentary spines are shorter, those of the actinal side of the jaws being much less conspicuous. The larger central spine of the actinal plates is also less prominent.

Pseudarchaster ordinatus Ver., sp. nov.

PLATE XXX. FIGURES 4, 4*a*, 4*b*.

A large species, having a broad disk, with the sides regularly incurved, and rather long, tapered, subacute rays, closely resembling *P. concinnus* in form and in the character of the upper side, but more spinose below.

Radii about as 1 : 2.8. Greater radius, 47 to 50^{mm}; lesser, 17–18^{mm}.

The abactinal paxillæ are regularly arranged, and evenly granulated, with very small, crowded, slightly elongated, round granules, of which twenty to thirty may occupy the central part; those around the margin are longer and divergent.

Upper marginal plates about 64 on each side of the body, much higher than long, encroaching considerably on the disk, sloping upward so as to form a bevelled margin. They are rather closely and finely granulated, like the abactinal plates. They have the narrow sutural grooves fasciolated.

Lower marginals similar to the upper in size and shape, but covered with small, acute, unequal spinules, and with one or two median vertical rows of larger appressed spines, of which there may be 8 to 10 or more on the larger plates.

The actinal plates mostly have a long, rather slender, acute central spine, surrounded by several small acute, erect spines. Many of those of the principal series have pectinate fascioles between them. Sometimes as many as 16 of these special fascioles occur on each interradial area.

The adambulacral plates bear a palmate furrow-series of seven or eight slender, divergent, nearly equal spines; one or two larger central spines on the actinal side; and an outer marginal curved row of several small acute spinules.

The jaws usually have an odd apical spine considerably larger than the rest, but it may be lacking on some jaws; there are about eight or nine spines in the furrow series, rather longer and larger than those farther out; and about seven to nine rather larger and longer actinal spines on each dentary plate, so that the jaws appear very spinose.

The genital pores are small but easily visible; they are situated opposite to the second pairs of dorsal marginal plates.

Taken by the Albatross in the Gulf of Mexico, at station 2396, in 335 fathoms (No. 18,438); also at station 2376, in 324 fathoms.

This species has a much thinner disk and more slender and more rapidly tapered rays with less massive plates that *P. intermedius*, or even *P. concinnus*.

The following additional species have been recorded from the East Atlantic :

Pseudarchaster annectens (Per.).

Astrogonium annectens Per., Exp. Trav. et Talism., p. 343, pl. xxiii, fig. 5, pl. xxiv, fig. 1, 1894.

Gulf of Gascony, 900 meters; station 213, 1888, 1384 meters.
This is very closely related to *P. intermedius* Sla.

Pseudarchaster hystrix (Per.).

Astrogonium hystrix Per., Exp. Trav. et Talism., p. 345, pl. xxiii, fig. 3, pl. xxiv, fig. 2, 1894.

Coast of Morocco, 840 meters, one example.
Very closely related to the preceding.

Pseudarchaster necator (Per.).

Astrogonium necator Per., Exp. Trav. et Talism., p. 350, pl. xxiii, figs. 1*a*, 1*b*, 1894.

Off the Azores, 1257 meters, one example.

Pseudarchaster Aphrodite (Per.).

Astrogonium Aphrodite Per., Exp. Trav. et Talism., pp. 342, 354, pl. xxi, fig. 2, pl. xiii, fig. 2, 1894.

Coast of Sahara, 1090 meters.

Aphroditaster gracilis Sla.

Aphroditaster gracilis Sla., Voy. Chall., xxx, p. 117, pl. xvii, figs. 1, 2, pl. xviii, figs. 7, 8, 1889.
Astrogonium gracile Per., Exp. Trav. et Talism., pp. 342, 354, 1894.

Off the Azores, 1000 fathoms.

Pseudarchaster tessellatus Sla. is from off the Cape of Good Hope.
P. Patagonicus (Per.) is from Patagonia, 283 meters.
P. discus Sla. is from Messier Channel, west coast South America, 147 fathoms.

A few species have been described from the Indo-Pacific region :

P. mosaicus Alcock and Wood Mason, is from the Andaman Sea, India, in 188 to 220 fathoms.

P. roseus (=*Mediaster roseus* Alcock, 1893, p. 98) is from the Laccadive Sea, in 740 fathoms.

Paragonaster subtilis Perrier.

Goniopecten subtilis Perrier, Bull. Mus. Comp. Zoöl., ix, p. 26, 1881. Mém. Etoiles de Mer, p. 253, pl. v, figs. 3, 4, 1884.
Goniopecten subtilis Sladen, Voy. Chall., xxx, p. 726, 1889.
Paragonaster subtilis Perrier, Exp. Trav. et Talism., p. 358, 1894.

The type of this species, from station 31, Blake Expedition, I have compared with specimens of *P. formosus* Ver., of similar size.

The two are very closely related, but in *P. subtilis* the adambulacral plates usually have, on the actinal surface, a rather long and stoutish acute central spinule; and the outer marginal spinules are also larger than those of *formosus*. On the proximal plates there are usually 6 or 7 furrow spinules and 8 or 9 on the actinal surface, all of which are stouter than in *formosus*. The spinules on the actinal surface of the dentary plates are also more numerous, larger and more divergent than in *formosus;* they form four rather irregular rows. The larger actinal paxillæ have 14 to 16 marginal granules, with 4 to 6 larger central ones.

Possibly a large series of specimens would compel us to unite the two, as only varietal forms of one species.

Four other Atlantic species of this genus have been described. They are as follows:

P. formosus (Ver.) 1884, p. 383); 1894, p. 257; 1895, p. 137.

Off East Coast of United States, 1396 to 2021 fathoms.

P. strictus Per., 1894, p. 363, pl. xxv, fig. 3.

East Atlantic, 3665 meters.

P. elongatus (Per.), 1885. 1894, p. 362, pl. xxi, fig. 3, pl. xxiv, fig. 4.

Off the Azores, 2115 to 4060 meters.

Perrier suggests that this may be only a variety of *P. subtilis* and that *P. strictus* may be the young of the same species.

P. cylindratus Sladen, Voy. Chall., xxx, p. 314, pl. li, figs. 3, 4, pl. liii, figs. 3, 4, 1889.

Off Cape Verde Islands, in 1850 fathoms. Closely related to *P. formosus.*

Rosaster Alexandri Perrier.

Pentagonaster Alexandri Perrier, Bull. Mus. Comp. Zoöl., ix, p. 22, 1881. Nouv. Arch. du Mus., vi, p. 238, pl. vi, figs. 3–8, 1884.
Rosaster Alexandri Per., Exp. Sci. Trav. et Talism., Echinod., p. 387, 1894.

This species has rounded, columnar, paxilliform abactinal plates, covered, like the marginal and actinal plates, with small spinules. Most of the upper marginal plates of the rays are in contact medially.

The genus *Rosaster* is evidently very distinct from *Paragonaster*. Perrier states that it has no pedicellariæ of any kind, but some of the larger specimens that I have examined have had a small number of simple pedicellariæ on the actinal plates.

The larger examples have two long, slender spines on the actinal side of the adambulacral plates.

It was taken at several stations by the Blake, in 84 to 1930 fathoms, and by the Albatross at a number of stations in the West Indies and Gulf of Mexico, in 182 to 980 fathoms.

INCERTA SEDES.

Hoplaster Perrier. Type, *H. spinosus* Per.

Hoplaster Perrier, 1882, Rapport, p. 32. Exped. Trav. et Talism., p. 323, 1894.

Form pentagonal with short rays. Marginal plates well-developed, not numerous, spinulated. An odd marginal interradial above and below. Abactinal and actinal plates angular, crowded, closely united, covered with a group of elongated spinules. No pedicellariæ observed. Adambulacral plates with three or four spinules in the furrow-series and an irregular group of spinules on the actinal surface. Jaws without a recurved spine.

The relations of this genus are doubtful. Perrier placed it next to *Gnathaster*, on account of the odd marginal plate, etc. (See p. 202). It may, perhaps, belong to Goniasteridæ, or be allied to *Lasiaster*. The details of its skeleton are not known.

Hoplaster spinosus Perrier, 1882, Rapport, p. 32. Exped. Trav. et Talism., p. 324, pl. xiv, figs. 2*a*, 2*b*, 1894.

Off the Azores, etc., 2995 to 3307 meters.

Only small examples are known.

Hoplaster lepidus (Sladen).

Pentagonaster lepidus Sladen, Voy. Chall., xxx, p. 275, pl. lvii, figs. 1–4, 1889.

This species agrees so closely, in all structural characters, with the type of the genus, that there can be little doubt that they belong to one genus. In fact, the present species might even prove to be an older state of the former, to judge from the descriptions. They both came from the same region and similar depths.

Off the Azores, 1000 fathoms.

Lasiaster Sladen. Type, *L. villosus* Sladen.

General form as in *Tosia* and *Goniaster*. Marginal plates well-developed, in both series, paired. No odd interradial. Marginal, actinal, and abactinal plates covered with groups of small, acute spinules.

The general appearance of this genus is similar to *Hoplaster*, with which it may, possibly, be related, though no odd interradials are present. M. Sladen refers the genus to the *Gymnasteridæ*.

Lasiaster hispidus (Sars) Sladen.

Goniaster hispidus M. Sars, Fauna litt. Norveg., iii, p. 72, pl. 8, figs. 24, 25, 1877.

Pentagonaster hispidus Perrier, Nouv. Arch. du Mus. d'hist. Nat., Ser. 2, vol. i, p. 84, 1878. Danielssen and Koren, Asteroidea, Norske Nordhavs-Exped. Zoöl., xi, p. 58, pl. xv, fig. 6, 1884.

Lasiaster hispidus Sladen, op. cit., p. 372, 1889.

Arctic coasts of Europe, especially in the Drontheim Fjord, in deep water.

The larger specimens are 72^{mm} in diameter.

Revision of the Classification of the orders Valvata and Paxillosa of Perrier, and especially of the Archasteridæ.

Archasteridæ Sladen, Voy. Chall., xxx, pp. 1–4, 1889. Perrier, Exp. Trav. et Talism., pp. 237–252, 1894.

In a former article (1894, pp. 266–269) I endeavored to show that this extensive group is probably not a natural family.

This opinion has been confirmed to some extent by the subsequent publication of Perrier's report, quoted above, in which he discussed, at considerable length, the characters of this "family," as contrasted with *Pentagonasteridæ*. He enumerated seven principal characters by which the two families are distinguished. It is sufficient to state

here that every one of these seven characters fails in certain cases, and that nearly all of them may occur in each family, so that there is no certain means of deciding in which family certain genera should be placed. Perrier, himself, admits something of the kind, but holds that the preponderance of the characters ought to determine the family in each case.

The recent discovery of new genera has so increased the exceptional cases, by revealing forms that are more or less completely intermediate between the two groups, that it has become difficult to define them in any satisfactory manner.

The two principal writers who have recently discussed the classification of these starfishes, Sladen and Perrier, have differed considerably as to the limits and characters of each group. Thus Sladen included the Odontasteridæ (as *Gnathaster*) and the genera *Mimaster* and *Leptogonaster* in the Pentagonasteridæ, but Perrier put all these in the Archasteridæ. On the other hand, Sladen puts *Pseudarchaster* and *Aphroditaster* in the Archasteridæ, but Perrier transfers them to the Pentagonasteridæ.

These are well-known genera that have been thoroughly studied by both writers, therefore we must conclude that the two so-called families are not really well defined, natural groups, otherwise such able investigators could hardly disagree to such an extent.

This question would be of less importance were it not for the fact that in the more general classification of Perrier, these two "families" belong to two distinct orders. The Archasteridæ he places in the order Paxillosa (op. cit., pp. 28, 29); the Pentagonasteridæ in the order Valvata.

The fact that the two so-called families run together, without definite limitations, would necessarily imply that these two "orders" are also badly limited or unnatural groups.

Almost the only special character by which the two groups can be distinguished, as limited by Perrier, will be the character of the pedicellariæ, which, however, are often lacking in both groups.

But the papilliform pedicellariæ of the Paxillosa, with two to four or more valves, apparently formed from modified spinules or granules, are also found in the *Valvata*. Sometimes such pedicellariæ are found associated with larger valvular pedicellariæ on the same specimen, in the genus *Nymphaster* and other genera, while well-formed, though small, bivalve pedicellariæ often occur on certain of the antarctic Gnathasterinæ, and on other species referred to Paxillosa.

Therefore, if this feature is to be the criterion, the Paxillosa should only include such groups as never have true bivalve pedicellariæ. The existence of paxilliform plates on the dorsal surface cannot be made an important character, for they occur in typical forms of Valvata. The development of terminal suckers on the ambulacral feet varies much in both groups, and depends mainly on the nature of the bottom inhabited.

The Paxillosa would be a more natural group if limited to the Porcellanasteridæ, Astropectinidæ, and the genus *Archaster*, while the rest of the Archasteridæ (Sla.) might go into the Valvata (sens ext.) However, it seems to me a more natural arrangement to consider these groups as the two suborders of one order, equivalent in rank to the three others proposed by Perrier. For this order Sladen's name, *Phanerozona*, might well be used, in a slightly restricted sense, the Asterinidæ and Gymnasteridæ being excluded.

The classification of the order as now proposed would be as follows:

Order **PHANEROZONA** Sladen (rest.).

Suborder I.—**Valvata** Perrier (sens ext.).

Family I.—Linckiidæ Perrier.
Family II.—Pentacerotidæ Gray (restr.).
Family III.—Antheneidæ Per. (restr.).
Family IV.—Goniasteridæ Forbes (restr.).
Subfamily I.—Goniasterinæ V., nov.=Pentagonasterinæ Sla. (*pars*).
Subfamily II.—Goniodiscinæ Sla.
Subfamily III.—Mediasterinæ V., nov.
Subfamily IV.—Pseudarchasterinæ Sla.
Subfamily V.—Hippasteriinæ V., nov.
Family V.—Odontasteridæ Ver. nov.=Gnathasterinæ Per. (*pars*).
Family VI.—Plutonasteridæ Ver.
Subfamily I.—Mimasterinæ Sla.
Subfamily II.—Plutonasterinæ Sla.
Subfamily III.—Pontasterinæ Ver., 1894.
Family VII.—Goniopectinidæ V., nov.
Family VIII.—Benthopectinidæ V.=Benthopectininæ Ver., 1894.

Suborder II.—**Paxillosa** Per. (sens. restr.).

Family IX.—Porcellanasteridæ Sla.
Family X.—Archasteridæ Vig. (restr. to *Archaster*).
Family XI.—Astropectinidæ Gray (restr.).
Family XII.—Luidiidæ V., nov.=Ludiinæ Sla.

It will be noticed than in the above arrangement the Archasteridæ of Perrier, 1894, has been divided into five distinct families (Families V, VI, VII, VIII and X). The larger number of genera are placed in the Plutonasteridæ, which includes three groups that appear to be of subfamily rank.

The synonymy given will sufficiently indicate the limits of the groups in most cases.

The new family, Goniopectinidæ, is proposed to include *Goniopecten* Per. (restr.), type *G. demonstrans*, together with an allied new deep sea genus *Prionaster* Ver., type *P. elegans*, with odd interradial marginal plates and a corresponding odd row of actinal plates. It is from the West Indies. The genus *Craspidaster* Sla., which I have not seen, probably belongs to the same family. In this group the adambulacral, actinal, and marginal plates are surrounded by special spinules united together by a web, so as to form very specialized fasciolated grooves. It is related to the Astropectinidæ, as well as to Pontasterinæ.

The family Benthopectinidæ includes, so far determined, only the genus *Benthopecten* Ver.=*Pararchaster* Sladen.

The family Odontasteridæ is proposed for *Odontaster*, *Gnathaster*, and allied forms, having one or two large recurved spines on the jaws, and also odd interradial marginal plates. It is equivalent to Gnathasterinæ Per., minus *Hoplaster*.

Archasteridæ is restricted to the typical genus *Archaster*, which is believed to be closely allied to the Astropectinidæ.

Family **ODONTASTERIDÆ** Ver., nov.

Gnathasterinæ (*pars*) Perrier, Exp. Trav. et Talism., pp. 244, 251, 1894.

Form either pentagonal or stellate with a broad disk. Marginal plates well-developed.

Jaws, each with a single, recurved, more or less hyaline median spine, or with two such spines, side by side. In the latter case one

of these spines arises from near the apex of each dentary plate. Both conditions sometimes occur, abnormally, on the same specimen.

An odd interradial marginal plate, above and below, on each side.

Abactinal surface covered with more or less paxilliform plates, parapaxillæ or protopaxillæ, with intervening large papular pores on the radial areas. The abactinal plates may bear clusters of more or less elongated spines, or a group of small granules. They usually form obliquely transverse lines on the rays, not always regular.

Actinal plates angular, covered either with spines or granules. Small simple pedicellariæ sometimes occur on the actinal or abactinal plates. They may have two, three, or four papilliform blades.

Adambulacral plates usually bear elongated spinules arranged in three or four pairs of small transverse rows, generally only two or three of the furrow-series are on each plate; sometimes only one. Dentary plates usually have elongated, acute marginal and apical spines. They are sometimes closely united along the median suture; in other cases (*Odontaster*), they are separated by a space covered only by membrane.

The marginal plates are covered either with spinules or granules; sometimes the upper ones are granulated and the lower spinulose, like the corresponding disk-plates; they usually have deep fasciolated sutures.

Perrier, 1894, instituted a sub-family under the name *Gnathasterinæ* to include the present group, together with some other forms (*Hoplaster*) in which no recurved jaw-spines occur. He based the group more particularly on the odd interradial marginal plate. But the latter character seems to me to be of less importance, for I have found it abnormally present in various species of *Tosia* and allied genera. (See under *Pyrenaster dentatus*, p. 167, above). Moreover in *Benthopecten*, which normally has an odd interradial plate, I have found it replaced by two plates, on some of the margins (see p. 218 below and pl. xxx, figs. 7, 7*a*).

Therefore, I have taken the presence of the recurved dentary spines as the special feature of the group.*

As the name *Gnathaster* is nearly a synonym of *Odontaster*, and may, therefore, be dropped from the system by future authors, it seems desirable to change the name of the group to *Odontasteridæ*.

Perrier has divided the group into three genera: *Gnathaster*, *Asterodon*, and *Goniodon*.

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* A similar recurved tooth is found in certain species of *Pterasteridæ*.

Asterodon Per. has a pair of dentary spines on each jaw.* Type, *A. singularis* (M. and T.). Peru and Chili.

Goniodon Per. has some of the distal marginal plates enlarged. A pair of recurved spines on each jaw. Type, *G. dilitatus* Per., New Zealand.

Gnathaster Sladen (restr.) has the marginal plates regularly decreasing. One recurved spine on each jaw. Type, *G. pedicellaris* Per.= *G. meridionalis* (t. Leip.), Cape Horn.

As thus limited and defined *Gnathodon* is identical with *Odontaster* Ver., of earlier date. The type cited, however, is not a typical *Odontaster*.

When Sladen established his genus *Gnathodon* he included in it all the known forms belonging to the three divisions proposed by Perrier. He did not designate any particular species as the type. His personal studies and detailed descriptions and figures were devoted to three Antarctic species, all of which would go in the genus, as restricted by Perrier.

Bell, 1893, combined all the known forms under the name *Odontaster* Ver., which is the earliest generic name in the group. The latter was based by me on a single species (*O. hispidus*), which is one of a group of species having very spinulose paxillæ and plates, and is apparently not strictly congeneric with *O. meridionalis* Smith (= *O. pedicellaris* Per.), which Perrier cites as the type of *Gnathodon*, 1894.

It seems to me unnecessary, therefore, to consider *Gnathodon* (Perrier, restr.) a synonym of *Odontaster*.

Since *Odontaster* was originally established for a more restricted group, Sladen's name was not originally truly synonymous with it. Therefore it may well be restricted to one of the other subdivisions included in it by him, as Perrier has done imperfectly.

Another division may be established for *G. elongatus* Sl., and *G. miliaris* Gray, in which the abactinal skeleton consists of pseudo-paxillæ, or low rounded plates covered with granules, while granules also cover the actinal and marginal plates, thus giving them nearly the same appearance as species of *Tosia* and allied genera, for which, indeed, some of them were formerly mistaken and described (under *Astrogonium* by Gray, and others; and under *Pentagonaster* by Perrier).

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* Leipoldt, 1895, figures an abnormal specimen of *A. singularis* in which two jaws have each but one median tooth (pl. xxi, fig. 7*c*).

Acodontaster Ver., gen. nov. Type, *G. elongatus* Sladen.

Gnathaster (*pars*) Sladen, Voy. Chall., xxx, p. 285, 1889. Perrier (*pars*), p. 244 (1894).

Odontaster (*pars*) Bell, Proc. Zoöl. Soc. London, p. 261, 1893. Leipoldt, Zeit. wissenschaft. Zoöl., lix, p. 614, 1895.

One odd median, recurved, hyaline spine* on each jaw, or angle of the mouth-frame. The two dentary plates are closely united along the suture.

Actinal, marginal and abactinal plates are covered with granules or short granule-like spinules.

Abactinal plates have the character of pseudopaxillæ, or are not truly paxilliform, nor much elevated. They form obliquely transverse rows on the rays. Papular pores are large in the radial areas.

The marginal plates decrease regularly in size distally. The adambulacral spines are arranged in several series; two of each series usually are situated on each plate.

Actinal plates form series in two directions. Adambulacral plates usually bear only two spines in the furrow-series. Pedicellariæ are not found in the type. The distribution is Antarctic.

The following species belong to this group.

Acodontaster elongatus (Sladen, 1889). Off Marion I.; off Heard I.; off Kerguelen I., etc., 50–150 fathoms.

Acodontaster miliaris (Gray, 1847). New Zealand.

Gnathaster Sladen (restr.). Type, *G. meridionalis.*

Gnathaster (*pars*) Sladen, Voy. Chall., xxx, p. 285, 1889. Perrier (*pars*), Exp. Trav. et Talism., p. 244, 1874.

Odontaster (*pars*) Bell, Proc. Zoöl. Soc. London, p. 261, 1893. Leipoldt, Arch. wissen. Zoöl., lix, p. 614, 1895.

A single hyaline recurved spine (movable?) on each jaw. The two dentary plates consolidated at the suture.

Abactinal plates are elevated, convex or capitate, and with radial basal processes. They are covered with a group of short spinules or with prismatic granules. They extend to the apical plate.

Dorsal marginal plates not very large, covered with granules or with small short spinules, like the disk. Ventral marginal plates and actinal plates covered with granules or minute spinules.

* According to Sladen's description these spines, in his species, are more closely united to the jaw than in *Odontaster*, and would hardly be movable. In the latter they are only attached by their bases, at the apex of the jaw, and are movable.

Adambulacral plates are narrow and usually have only two furrow spines; several other pairs are borne on the actinal side of each plate.

G. pilulatus Sladen also belongs to this restricted group.

G. pedicellaris Per., from Cape Horn, is placed as a synonym of *meridionalis* Smith by Leipoldt, as are, also, *G. Grayi* (Bell) and *G. pilulatus* Sladen. All the species are Antarctic.

Odontaster Verrill.

Odontaster Verrill, Amer. Journ. Science, xx, p. 402, 1880. Proc. U. S. Nat. Mus., xvii, p. 262, 1894. Amer. Journ. Sci., xlix, p. 136, 1897.
Gnathaster Sladen (*pars*), Voy. Challenger, vol. xxx, Asteroidea, p. 285, 1889. Perrier (*pars*), Exp. Trav. et Talism., p. 244, 1894.
Odontaster Bell (*pars*), Proc. Zoöl. Soc. London, p. 260, 1893.

A single, odd, hyaline, recurved movable spine on the apex of each jaw. Dentary plates large, separated by an open, fusiform space covered by membrane. Abactinal surface covered with elevated, convex or clavate paxilliform plates, or parapaxillæ, which usually bear clusters of elongated spinules, like true paxillæ; their bases are stellate; upper marginal plates are usually finely spinulated.

Lower marginal plates and actinal plates are covered with acute, more or less elongated spinules.

Papular pores are generally large and placed singly in the angles around the radial paxillæ. The radial abactinal plates form more or less evident obliquely transverse rows and extend nearly or quite to the apical plate.

The odd interradial marginal plate is usually triangular or wedge-shaped. Simple pedicellariæ occur rarely.

The adambulacral plates usually bear several rows of spines; usually three or four in the furrow-series, rarely but two.

The species, so far as known, are from the North Atlantic.

The open suture between the dentary plates of the jaws; the movable hyaline spine, attached only by its base, at the apex of the jaw, together with the very spinose character of the abactinal paxillæ and marginal plates, separate this genus from its allies. The marginal plates are also larger than in most of the other groups, and the adambulacral plates bear usually three or four spines in the furrow-series.

A reexamination of the numerous specimens of this genus formerly collected by the U. S. Fish Commission Steamer Albatross, off our coast, convinced me, several years ago, that two species were comprised under the name of *O. hispidus* in our earlier lists, and

probably in the collections sent to various museums by the U. S. Fish Commission and National Museum. Two examples of another new species was also discovered in the same collections. I have, therefore, thought it desirable to prepare comparative descriptions of these two new species, and to give morphological figures of the three forms, for comparison.

Odontaster hispidus Verrill.

Odontaster hispidus Verrill, Amer. Journ. Sci., vol. xx, p. 402, 1880. Proc. U. S. Nat. Mus., vol. xvii, p. 263, 1894. Amer. Journ. Sci., vol. xlix, p. 136, 1895.

PLATE XXIX. FIGURES 3, 3*a*.

Form depressed, stellate, with a rather broad disk. Radii vary in proportion from 1:2 to 1:3. The rays taper regularly and are subacute.

The marginal plates are only moderately developed and do not encroach much on the disk, either above or below. In large examples there are about 37 to 39 on a side, in each series. They are convex and separated by wide and rather deep sutural grooves. The upper and lower nearly coincide. The upper ones are squarish, with rounded angles; the lower ones, along the disk margin, are higher than long. The odd interradial one is somewhat wedge-shaped, and only a little smaller than those adjacent to it.

The marginal plates of both series are densely covered with small elongated, divergent spinules which over-arch and partly conceal the sutural furrows. The spinules on the upper plates are slender and acute. Those on the lower plates, especially those on the actinal side, are longer and much stouter, terete and tapered, subacute or acute. When the spinules are removed the marginal plates are covered with small hemispherical elevations, where the spinules were attached. Those of the upper plates are smaller and more crowded.

The abactinal plates are round at top, convex, well separated; those of the radial areas and center of the disk are elevated, with a somewhat capitate round top, which is covered by a dense cluster of slender, elongated, acute divergent spinules.

Between most of the radial plates, over a large area, there are moderately large papular pores, about six around each plate, placed singly in most cases.

Smaller pores are scattered over the center of the disk, but they are absent from the small interradial areas and from the distal part of the rays.

The actinal plates, when denuded of spines, are numerous, decidedly convex, with deep sutural grooves between them; their surfaces are covered with uneven irregular elevations, where the spines were attached. They are arranged in about five rows parallel to each ambulacral furrow. The first row extends nearly to the tip of the ray; its plates are larger and rather more square than those of the next row. The interradial plates become small, rounded and crowded. The actinal plates all bear dense groups of rather stout, elongated, tapered, mostly acute or subacute spinules, essentially like those of the lower marginal plates.

The adambulacral plates are transversely oblong, rather narrower than the adjacent actinal plates, and have, like the latter, a tuberculated surface. Each one, proximally, bears two, or more often three, unequal spinules of the furrow-series, but more distally they bear only two, nearly equal ones. On the actinal side each plate bears about four or five quite similar spines, which sometimes seem to stand, more or less distinctly, in pairs. These spines, like those of the furrow-series, are essentially like those of the actinal plates, in size and form.

The jaws are rather large, rhombic; the two dentary plates are separated by a rather wide sutural furrow covered with membrane; they are covered with spines on the margin and actinal side, like those of the adambulacral plates. The median recurved spine is large, somewhat compressed; the distal part is hyaline and very acute.

A large example has the greater radius 55^{mm}; lesser, 16^{mm}. Another has the greater radius 42^{mm}; lesser, 14^{mm}.

This species has been taken by the U. S. Fish Commission at many localities, from off Martha's Vineyard to Florida, in 43 to 480 fathoms and more.

It is easily distinguished by the small marginal plates and stout actinal spinules.

Regularly 4-rayed and 6-rayed specimens have been taken.

Odontaster setosus Ver., sp. nov.

PLATE XXIX. FIGURES 1—1*c*, 2.

Form depressed, stellate, with a broad disk. Sides regularly incurved. Radii about as 1:2, somewhat variable. The marginal plates are pretty well-developed and encroach considerably upon the disk, above and below. They are transversely oblong, distinctly higher

than broad, and separated by deep sutural grooves. They are decidedly larger than in *O. hispidus* and not so square. The upper and lower ones correspond closely in size and position, so that the sutural grooves are continuous. Large examples have about 35 in each series on each side of the body.

In some specimens as many as five or six of the distal dorsal marginal plates are in contact medially; in others all are separated, the abactinal plates reaching even the apical plate.

The marginal plates, above and below, are thickly covered with large numbers of small, slender, acute spinules, those near the margins divergent and forming fascioles. The spinules of the upper plates are rather smaller and more numerous than those of the lower ones, but there is no such difference in character as in *O. hispidus*. When the spinules are removed the plates are thickly covered with minute tubercles.

The abactinal radial plates are well separated, small, paxilliform with a rounded, convex or capitate top, covered with a cluster of slender, acute, setiform, divergent spinules.

The papular pores are large and conspicuous and occupy large areas; they are placed singly. The actinal plates are rather numerous, rhombic, finely tuberculated, arranged in three or four rows parallel with the ambulacra; the first series extends to about the seventh marginal plate. They are covered with dense clusters of slender, acute, setiform spinules, like those of the upper surface but longer.

The adambulacral plates are transversely oblong, narrower than the adjacent actinal ones. They bear each three or four slender furrow spinules in a nearly regular row, and a dense group of 10 to 12 or more, somewhat longer, slender spinules on the actinal side. The latter are similar to the actinal spinules, but rather larger and less acute.

The dentary plates bear marginal and actinal spines, similar to those of the adambulacral plates, but those at the apex are shorter, prismatic and blunt, while there are usually two or three near the sides that are larger than the rest and somewhat curved. The plates are separated by wide sutural grooves.

The recurved spines are compressed and often somewhat curved; the distal end is hyaline, suddenly narrowed or acuminate, and usually very acute.

One of the larger specimens has the greater radius 37^{mm}; lesser, 18^{mm}. Another has the greater radius 32^{mm}; lesser, 17^{mm}.

This species was taken by the U. S. Fish Commission Steamer Albatross, at many stations, from off Martha's Vineyard to the Carolina coasts, in 56 to 400 fathoms or more. It was often associated with *O. hispidus.*

In form and general appearance it resembles *O. hispidus,* but is easily distinguished by the higher marginal plates, and especially by the slender setiform spinules of all the plates on the under side.

Odontaster robustus Ver., sp. nov.

PLATE XXIX. FIGURES 4, 4*a*.

Form broadly stellate, with short, rapidly tapered rays and thick margins. The sides are regularly incurved. Radii about 1 : 1½.

The marginal plates are larger and thicker than in the two preceding species. Those of the two series correspond closely in size and position. There are 27 of each series on each side of the body, in the type. They encroach considerably upon the disk, both above and below, and rise distinctly above the abactinal plates, thus forming a conspicuous margin. They are transversely oblong, about twice as high as broad. About four pairs of the distal dorsal plates are in contact medially.

The odd interradial plates are small and wedge-shaped, and do not reach the marginal sutural groove, but in this groove, opposite the odd interradials, there may be a small, odd, ovate plate. This is lacking, or very small, on two of the margins of the type. The sutural grooves are narrow and deep, with marginal fascioles of small slender spinules. Both series of marginal plates are thickly covered with small, slender, setiform spinules, those of the lower series somewhat larger and longer than those of the upper ones.

The abactinal plates are small, round, well separated, paxilliform. Those of the radial areas have a rather high column, somewhat capitate, with the top somewhat convex and covered with a divergent cluster of small, slender, acute, setiform spinules.

The papular pores are conspicuous and occupy five large radial and a disconnected central area; those in the central parts of each area are much larger than those at the edges; about six surround each plate.

The actinal plates are squarish and form about four rows parallel with the ambulacra; they are separated by rather wide grooves, and each bears a thick group of elongated, slender, setiform spinules.

The adambulacral plates are rather narrower than the adjacent actinals. Each bears four or five slender spinules in the furrow series; these are terete and rather larger than the actinal spinules; on the actinal side there is a group of 12 to 16 slender spinules, those next the furrow series about the same as the latter in size and form; the outer ones are rather smaller.

The dentary plates are separated by wide open sutures; their marginal and surface spinules are like those of the actinal plates.

The recurved spines are conspicuous and not much compressed, with regularly tapered, very acute, hyaline tips.

The type specimen has the greater radii 33 to 35^{mm}; lesser, about 20^{mm}.

The type (No. 9758) was taken in 1881, by the Albatross, off Martha's Vineyard, at station 994, in 368 fathoms, mud. A smaller specimen (No. 18423) was taken in 1885, at station 2586, in 328 fathoms, in the same region.

This species is easily distinguished from the two preceding by the thicker margin and disk, shorter rays, larger and fewer marginal plates, more numerous adambulacral spinules, etc.

Family **PLUTONASTERIDÆ.**

Plutonasterinæ (sub-family) Sladen, op. cit., pp. 2, 60, 1889. Perrier, Exp. Trav. et Talism., p. 251, 1894.

This group appears to be sufficiently distinct to be regarded as a family. The great group called the family *Archasteridæ* by Sladen and by Perrier is so heterogeneous that it cannot be definitely defined, as already explained by me. (See p. 199.)

In the present group the form is stellate, the rays often long and tapered. The abactinal plates are usually very numerous, in the form of columnar parapaxillæ or protopaxillæ, covered with small divergent spinules. They generally have no very definite arrangement and the median radial series is often not distinguishable.

The marginal plates are generally well developed and paired, but are sometimes small. They often bear one or more acute spines.

The actinal plates are imbricated and generally form rows running from the ambulacral to the marginal plates.

The pedicellariæ, when present, are usually of simple structure, with two to four papilliform blades. See pl. xxvii, fig. 6. They seem to be lacking in many species. Supra-ambulacral plates are present.

Nearly all the species of this group are from the deep sea. None are littoral. For the subdivisions see p. 200.

Plutonaster Agassizii Verrill.

Archaster Agassizii Verrill, Amer. Journal Sci., vol. xx, p. 403, 1880.
Plutonaster rigidus Sladen, op. cit., p. 91, pl. xiv, figs. 3, 4; pl. xv, figs. 3, 4, 1889; also var. *semiarmatus*, op. cit., p. 94.
Plutonaster bifrons (*pars*) Sladen, op. cit., p. 88, 1889 (very young example).
Plutonaster Agassizii Verrill, Proc. Nat. Mus., vol. xvii, p. 248, 1894. Amer. Journ. Sci., xlix, p. 131, 1895.

Plate XXVII. Figure 6.

This species is intimately related to *P. bifrons* and other forms that have been described from the East Atlantic. Probably several of these species will have to be united eventually. It is also very closely allied to *P. intermedius* (Per.) of the West Indies, with which I have compared it. From the latter it appears, however, to be distinct.

Our specimens occasionally have one or two small pedicellariæ on the actinal side near the jaws (see pl. xxvii, fig. 6). They have three or four simple papilliform blades, and are very similar to the ordinary form found on *Dytaster*.

Perrier and Sladen both state that no pedicellariæ are found in this genus.

Four-rayed and six-rayed specimens occasionally occur.

Taken at 103 stations between N. lat. 41° 53′ and 35° 45′ 23″; in 182 to 1700 fathoms. Most common in 300 to 1200 fathoms.

Plutonaster efflorescens Perrier.

Archaster efflorescens Perrier, Etoiles de Mer, p. 255, 1887.
Plutonaster efflorescens Perrier, Trav. et Talism., p. 322, 1894.

The type of this species from station 29, 955 fathoms, Blake Expedition, when examined by me in 1896, was in a very poor state of preservation; all the rays but one were broken off and the granules of the disk were largely rubbed off.

It is a young specimen. The radii are only 17^{mm} and 5·5^{mm}, so that the adult specific characters are not developed.

The rays are relatively large for so young a specimen, slender, tapered, and narrow distally, being more like those of *Dytaster* than *Plutonaster*.

Marginal plates are 34 to 36 on each side of the body, small, squarish, not oblique; the upper ones extend a little on the actinal side of the disk. They are covered with minute raised spinules, which are not crowded; along the interradial margins each usually bears a slender tapered, conical spine, about as long as the breadth of the plate. The marginal plates are convex with a distinct groove between them.

The lower marginal plates extend much farther back from the margin than the dorsal ones, but they have the same fine spinulation; there are distinct marginal fascioles between them; most of the distal and some of the proximal plates also have a central spine, like those of the dorsal series, but rather longer.

The apical plate is relatively large, elongated, ovate, with a large proximal notch.

The abactinal paxillæ are numerous, very small, round, nearly uniform in size; when rubbed the plates are convex and elevated, well separated; three or four rows continue even to the apical plate. There is no distinct median dorsal series; each plate bears a group of four to eight (usually six) very small, slightly elongated, divergent spinules, forming regular stellate clusters, without any evident larger central spine.

The actinal plates are rather numerous, forming triangular areas; they are similar to the abactinal plates, but rather larger; each usually bears six to eight small, rough, divergent spinules, in a stellate group. They extend to about opposite the fourth or fifth adambulacral plates, and do not form evident radial rows.

The adambulacral plates are relatively large; the inner or furrow margin is convex and along the middle portion of the groove of each plate four or five slender, elongated, rough, terete furrow-spines on its convex edge, and six to eight shorter and smaller, divergent spinules on its actinal surface, forming two or three irregular transverse rows, or else an irregular roundish cluster.

The dentary plates are rather prominent, sub-carinate, and are covered with numerous small, slender spinules on the actinal surface; on the furrow margin there are numerous small slender spinules and about six larger, convergent, apical ones. No pedicellariæ could be found.

Although this is evidently the young of some large species, it differs decidedly from the young of *Dytaster insignis* and *D. grandis*, of the same size, with which I have compared it directly. It has shorter rays; single marginal spines; much smaller and more finely spinulose dorsal paxillæ; more numerous actinal plates, with finer and more numerous spinules; more numerous spinules on the dentary plates; more nearly equal and regular and more slender furrow spines on the adambulacral plates; the edge of the latter is less prominent, so that the furrow-series is less broken. In these characters it agrees better with *Plutonaster* than with *Dytaster*.

It should probably be referred to *Plutonaster*, as has been done by Perrier (1894), but it does not agree with the young of either of the adult forms known from the American coasts.

Perrier (1894) seems inclined to unite this with *pulcher* (Per.), though he points out a number of differences. The latter is also quite young. Their identity seems to me very doubtful, after a comparison of the types.

Family GONIOPECTINIDÆ Ver., nov.

Stellate with elongated rays; marginal, adambulacral and actinal plates bordered with peculiar pectinate spinules united by a web-like membrane, and thus forming specialized, continuous fascioles. Surface of the marginal plates usually smooth or with a few scattered granules, sometimes entirely granulated, usually covered with a thin membrane.

Marginal plates large, regularly paired; the sutures corresponding above and below; sometimes they are spinose. There may be an odd interradial marginal plate in each series (*Prionaster*).

Abactinal plates are paxilliform or columnar and covered with small spinules. They are arranged in oblique transverse rows on the rays. Actinal plates form radial series, usually double (single in *Craspidaster*), running from the adambulacral to the marginal plates, with deep fasciolated grooves between them, continuous with the fasciolated grooves between the marginal plates.

The adambulacral plates project over the ambulacral furrows, forming constrictions; they bear a curved or angular series of furrow spinules united by a basal web.

The jaws are rather large and very prominent, with an open suture. They bear two or more enlarged apical spines, and more or less numerous smaller spinules on the actinal side.

Craspidaster Sladen appears to belong to this family.

Goniopecten demonstrans Perrier.

Goniopecten demonstrans Per., 1881, p. 24. Etoiles de Mer, p. 249, pl. iv, fig. 5, 1884. Exp. Trav. et Talism., p. 295, 1894.

Plate XXVII. Figure 5.

The genus *Goniopecten*, as originally defined by Perrier, included *Plutonaster* and other forms now regarded as very distinct genera. But later (1894, p. 294) he restricted the genus to the single type, *G. demonstrans*. This was also done by me independently, in 1894 (p. 249).

The genus is very peculiar in appearance, owing to the smooth plates and curiously fasciolated sutural grooves.

It is, however, very much like the new genus *Prionaster* in appearance, but it has a fasciolated sutural furrow running from the suture of the jaws to the suture between the first pair of marginal plates.

It has no odd interradial marginal plates, which are present in *Prionaster*. The dorsal marginal plates do not bear spines as in the latter. It has a large madreporic plate with fine radial gyri.

The dorsal nephridial pore is surrounded by a large number of very small paxillæ, which form a low central prominence (probably much more elevated in the young). The papular pores are numerous, small, arranged regularly, about six around each paxilla, over most of the disk and on wide basal radial areas, but even in the basal regions they are lacking along the three or four median radial rows of paxillæ and do not reach the ends of the rays.

The paxillæ are very numerous on the disk, smaller centrally; they are high, with rounded or elliptical tops, and covered with a group of very small, short, blunt spinules, of which one to three are central. Distally the paxillæ become narrow-elliptical and very small. On base of the rays they form obliquely transverse rows.

The marginal plates are mostly smooth except around the margins, and covered with thin membrane; distally on the rays they bear minute scattered granules. Around their margins there is a regular rim, formed by the regular row of webbed spinules, which project over the edges of the sutural grooves. In these grooves there are several rows of much finer slender spinules. The apical plate is rather large, obconic, unarmed.

The actinal plates are large, angular, of various forms, not numerous; they extend out to about the 12th adambulacral plate, there being but a single row of small ones beyond the 7th. They form, proximally, double series, the two united rows corresponding to each marginal plate, but with from $1\frac{1}{2}$ to $2\frac{1}{2}$ adambulacrals. The actinal plates are flat and most of them bear from 1 to 3 minute scattered spinules, besides the marginal fasciolated row.

The adambulacral plates proximally have an oblique, angular furrow-series of 9 or 10 slender, divergent spines, webbed together at base. Farther out, about the middle of the ray, the series becomes more regularly convex and more prominent, with 10 to 12 smaller and more slender spinules, which sometimes, in dry specimens, nearly meet across the furrow, leaving large roundish or elliptical spaces for the passage of the adambulacral feet, which are very large and tapered, but without any sucker. The actinal margin of the adambulacral plates has one or more series of small, stout, divergent spinules, webbed together and fasciolated.

The jaws are very prominent, elliptical in outline. There are two or four tapered apical spines, much larger than the rest; the furrow-series is convex and contains 9 or 10 small spinules, like those of the adambulacrals. The elevated actinal surface is covered with many small, acute, spaced spinules, in three or four irregular rows.

No pedicellariæ could be found.

A large specimen has the larger radius, 115^{mm}; lesser, 21^{mm}.

Taken by the Blake Exped. in 358 fathoms, off Santa Cruz, etc., and by the Albatross in the West Indies and Gulf of Mexico, at several localities, in 335 to 347 fathoms.

I have compared the Albatross specimens with the types of Perrier from the Blake Expedition.

Prionaster Ver., gen. nov.

Stellate with long, tapered, squarish rays, high at base.

Abactinal paxillæ are arranged on the rays, in obliquely transverse rows, about four rows to each marginal plate ; they are small, high, rounded or elliptical, with a terminal cluster of small spinules.

Marginal plates large, high, not encroaching much on the disk, those on the interradial regions much higher than those of the rays. There is an *odd interradial plate* above and below, similar to the others in size and shape. The upper and lower plates correspond accurately even to the end of the ray. The proximal upper ones mostly have a central, acute, movable spine near the upper end. The lower ones may also bear a small spine. All are margined by a very regular series of small pectinate spinules, webbed together. Some of them may bear groups of minute granules.

The actinal plates are not numerous, flat, covered with thin membrane and with a few small scattered spinules, and a marginal series webbed together, so as to form fascioles. They are arranged in double series ; the series are separated by the fascioles, but the two rows of a series are not. An *odd interradial series*, with two rows of plates, runs from the jaw and first adambulacral plates to the odd interradial marginal plate. (See Plate XXVII, figure 4*a*.) The other series correspond each to a marginal plate, but have no regular relation to the adambulacrals.

The jaws are very prominent, with a large sutural groove. They have each two large apical spines and a row of sutural spinules. The adambulacral plates are large and project far over the furrow, so that the spines meet across it. They have a furrow series of numerous small spinules, webbed together ; their lateral and outer margins have smaller webbed spinules.

Prionaster elegans Ver., sp. nov.

PLATE XXVII. FIGURES 4, 4*a*, 4*b*, 4*c*.

Disk small; sides high and vertical, evenly incurved; rays high and nearly square at base, tapering regularly to the slender tips.

Radii as 1 : 5. Greater radius, 70^{mm}; lesser, 14^{mm}.

The marginal plates are oblong and much higher than long on the disk, but gradually become squarish on the rays. The upper and lower are exactly coincident, so that the vertical sutures are continuous. Their sides are nearly perpendicular and they encroach only a short distance on the disk, but at the middle of the rays each series is about as wide as the actinal area; distally, near the tips of the rays, they are separated only by a single row of very small paxillæ. The distal plates bear groups of small spaced granules near the upper end. Each of the upper ones, except on the distal third of the rays, bears a small, movable, tapered, acute spine at the upper angle; those at the base of the rays are longer than the rest. Some of the lower marginal plates of the rays have a similar, but smaller, spine at the lower angle and near the distal edge of the plate; most of the interradials have also a small cluster of minute granules near the lower end. All the marginal plates are bordered by a very regular and even series of small spinules webbed together to their tips. Those of the upper plates are much more numerous, finer and closer, and evenly pectinate; they nearly touch across the grooves. Those of the lower plates stand a little apart and are more divergent, about half as many in the same space as on the upper plates, and very similar to those between the actinal plates. The apical plate is large, prominent, oblong, with the inner end acute-angled.

The actinal plates are irregular in size and form, but mostly have curved outlines; they are partially concealed by a thin membrane, and many of them bear a very small subcentral spinule. All are bordered on that side next the fasciolated grooves by a row of appressed, slender, webbed spinules, which nearly or quite meet across the grooves; the latter are continuous with the grooves between the marginal plates and with those between and back of the adambulacrals. The actinal areas are not large and extend to about the eighth adambulacral. The median odd series consists of two closely united rows of about six each, the distal ones becoming very small. The next series contains a row of five plates and one of three similar plates; this series corresponds to the second and third adambulacrals. The next series, corresponding nearly with the

fourth adambulacral, has three plates in one series and two in the other. Beyond this the plates are few and irregular.

The adambulacral plates are broad and roundish, the proximal ones quite oblique ; their furrow edge projects over the furrow and bears a row of 10 to 12 small, slender, acute spinules, which are somewhat divergent and are webbed together for about half their length ; they meet or interlock across the furrow, leaving rounded or ovate open spaces between them for the passage of the large and tapered ambulacral feet. These spinules become very small and slender distally, but still meet across the furrow. On the outer and lateral margins of the plates there is also a series of divergent, webbed, fasciolated spinules like those of the actinal plates.

The jaws are oblong and very prominent on the actinal side ; each half has an actinal sutural row of very small spinules, and some additional ones on the surface. The furrow-series contains about ten spinules, increasing in length toward the apex of the jaw, where there are two much larger and longer, acute oral spines.

The madreporic plate is rather large, with fine gyri. The dorsal nephridial pore is situated in the center of a low elevation composed of very small, round paxillæ.

Taken by the Albatross at station 2401, in the Gulf of Mexico, in 142 fathoms. (No. 18,428.)

Family **BENTHOPECTINIDÆ** Ver., nov.

Benthopectininæ Ver., Proc. Nat. Mus., xvii, p. 245, 1894.

Benthopecten spinosus Verrill.

Benthopecten spinosus Verrill, Amer. Journal Sci., vol. xxviii, p. 218, 1884 ; Explorations made by the Albatross in 1883, in Annual Report, U. S. Comm. of Fish and Fisheries, pp. 519 [47], 543 [41], 1885. Proc. Nat. Mus., vol. xvii, p. 245, 1894. Amer. Journ. Sci., xlix, p. 129, 1895.

Pararchaster semisquamatus var. *occidentalis* Sladen, Voyage of the Challenger, vol. xxx, p. 10, 1889.

Pararchaser armatus Sladen, op. cit., p. 19, pl. 1, figs. 5, 6 ; pl. 4, figs. 5, 6, 1889.

Plate XXX. Figures 7, 7*a*.

This species was taken north of Cape Hatteras, at 62 stations, between N. lat. 42° 47′ and 35° 10′, in 721 to 2021 fathoms, by the U. S. Fish Commission. Most common in 1200 to 1600 fathoms.

It was also taken in the Gulf of Mexico, station 2380 and station 2381, in 1430 and 1330 fathoms, and off Jamaica, station 2127, 1639 fathoms.

One specimen of this species (No. 15,570) is remarkable for having, on one of the interradial margins, a pair of plates in place of the usual odd median plate.

Figure 7, plate XXX, represents the abnormal segment of this specimen, with the jaw and corresponding pair of marginal plates (*m*, *m*), and figure 7*a* represents a normal segment and jaw of the same specimen, with the odd marginal plate (*m*).

Family **ASTROPECTINIDÆ** Gray.

Blakiaster conicus Perrier.

Blakiaster conicus Per., 1881, p. 28. Etoiles de Mer, p. 265, pl. ix, fig. 2, 1884.

Leptoptychaster conicus Per., Exp. Trav. et Talism., pp. 242, 243. 1894.

Plate XXVII. Figure 7.

Perrier, in his later report, has united this genus with *Leptoptychaster*, but it seems to me sufficiently distinct, though doubtless they are closely allied. In this genus the actinal plates are not arranged in distinct radial series, nor do they have such well developed fascioles between them. On the contrary, they have a rather irregular, crowded, tesselated arrangement, the plates being roundish or polygonal, pretty closely united, without deep, sutural, fasciolated furrows. The marginal plates, also, have only rudimentary fascioles. The jaws are stout and evenly convex, instead of thin and carinate. The dorsal paxillæ are larger, rounded, and more regular.

There is a distinct dorsal nephridial pore or "anus." The dorsal papulæ are large, five or six around each plate, except on the distal half of the ray and on the small interradial areas.

The lower marginal plates have three or four larger and longer spines on the border.

There are also, on some of our specimens from off Havana, a number of pedicellariæ. Those on the actinal and adambulacral plates have four to six convergent papilliform blades, similar to the surrounding spinules, but rather stouter and blunter (see pl. xxvii, fig. 7). Similar ones, but smaller, with three or four blades, occur on the marginal and abactinal plates.

West Indies and Gulf of Mexico, 92 to 175 fathoms.

Sideriaster Ver., gen. nov.

Form broadly stellate with a very large disk; dorsal surface convex, and capable of inflation, closely covered with uniform, stellate paxillæ. Upper marginal plates small, entirely lateral.

Interradial actinal areas are large, with numerous plates, the distal ones extending to the distal third of the rays. They are arranged in single radial series, each series usually corresponding to an adambulacral plate and most of them to a marginal plate, but some of the series are short and do not reach the margin, there being more adambulacral than marginal plates proximally, but distally they generally correspond in number, though there are sometimes, locally, two marginals to one adambulacral. These plates are covered with granules, and have divergent, fasciolated spinules along their radial margins, thus forming fasciolated grooves that are coincident with those between the marginal plates.

The abactinal paxillæ are large, closely arranged, and nearly uniform in size and shape, regularly stellate, with short, even spinules.

The madreporic plate is *very large*, round, flat, fully exposed, and has very numerous, thin, radiating gyri.

Papular pores are very numerous and are arranged singly, about six around each plate over the whole of the disk and rays, even close to the ends.

There is no distinct dorsal nephridial pore visible, nor do the central plates differ in size from those of the disk in general.

Marginal plates are small and not prominent. The upper ones are entirely confined to the margin, and are granulated, without spines. The lower ones form the lower part of the margin, but extend also on the disk below; they are spinules with a median row of larger spines.

The adambulacral plates have a prominent furrow angle, on which there is a large, median, odd compressed spine; at each side of this there are, in the furrow-series, two or three erect flattened spines; a stout spine occurs on the center of the actinal side, with a single or double row of shorter flat spines back of it.

The jaws are large, not very prominent, covered with numerous short, blunt spinules and having furrow spinules like those of the adambulacral plates.

This remarkable genus seems to be very distinct from all known forms, but clearly belongs to the Astropectinidæ. Its very broad convex disk and large actinal interradial areas and small marginal plates are exceptional; and so is the very large madreporic plate.

Sideriaster grandis Ver., sp. nov.

Plate XXX. Figures 8, 8*a*, 8*b*.

Large, regularly five-rayed, with a broad, somewhat inflated disk, regularly and broadly incurved at the sides. The rays are rather long and rapidly tapered. Radii as 1:3.4. Greater radii, 133–138^{mm}; lesser, 40^{mm}.

The margin is formed mostly by the upper plates, which do not extend at all upon the upper side. They are small and short, those on the interradial margins shortest and highest, at least four times as high as long. They are covered with coarse rounded granules, and bordered with fascioles of slender spinules. The lower marginals are of the same length and extend on the under side considerably. They are covered closely with small appressed, flattened spinules, largest centrally, grading laterally to the marginal fasciolated spinules. On the middle of each plate there is a vertical row of about four stout, tapered, more or less flattened, acute spines.

The abactinal paxillæ are round and high, remarkably uniform in size, arranged on the rays in imperfect, transverse, oblique rows. They bear a round, rosette-like cluster of rather coarse, short, clavate or capitate, divergent spinules, of which one is usually central, with 6 or 7 in a circle around it, while about 15 to 18 form the marginal row, interlocking with those of the adjacent plates, so as to conceal the papular pores. The latter are rather large and regularly arranged over the whole disk and nearly to the ends of the rays, usually six around each paxilla. The bases of the paxillæ appear stellate.

The madreporic plate is remarkably large and flat or slightly concave, with very numerous and thin radiating gyri.

The actinal plates are granulated nearly like the upper marginal plates. Other under parts have been described above under the generic description.

Pedicellariæ occur in small numbers on the adambulacral plates and on the first row of actinals. They have two or three short, stout, flattened, spinuliform blades, similar in size to the adjacent spinules.

One specimen (No. 10,877) was taken by the Albatross at station 2378, in Gulf of Mexico, in 68 fathoms.

Family **PTERASTERIDÆ** Per.

Hexaster obscurus Perrier.

Hexaster obscurus Per., Mem. Soc. Zool. France, iv, p. 267, 1891. Res. Camp. Sci., xi, p. 41, pl. iii, figs. 1, 1*a*, 1896.
Pteraster (*Temnaster*) *hexactis* Verrill, Proc. Nat. Mus., vol. xvii, p. 175, 1894.
Temnaster hexactis Verrill, Amer. Journ. Sci., xlix, p. 202, 1895.

There can be no doubt that the genus and species described by Perrier is the same as that described by me. Both were from the same region and nearly the same depth.

The original description by Perrier (1891) was overlooked by me when I described the species in 1894.

Only one specimen was taken by the Albatross, in 57 fathoms, at station 2433, N. lat. 43° 05′; W. long. 50° 43′, off Newfoundland.

It was taken by the Hirondelle, off Newfoundland, in 155 meters.

Hymenaster regalis Ver., 1894; var. **Agassizii** nov.

Large, swollen, polygonal, with short rays, and with concave interradial areas. The interradial margins are prolonged into a broad, soft web. Abactinal pore small, regular, five-angled.

Adambulacral spines three in a series, appearing rather stout and club-shaped at the tip, in the alcoholic preparation. The whole under side of the body is covered with a thick fleshy membrane.

The dorsal surface is covered with prominent, regularly arranged, well spaced, slender, acute spines.

Color, in alcohol: under side deep pink or rose-color; upper side somewhat paler pink. This species was taken by the Blake Expedition, off Martha's Vineyard, N. lat. 41° 24′ 45″, in 1242 fathoms, 1880.

Family **ASTERINIDÆ** Gray.

Marginaster austerus Ver., sp. nov.

Pentagonal with five short, triangular, subacute rays; interradial margin incurved. Dorsal surface thickly covered with small and short, rough spinules, on crowded indistinct plates.

Papulæ rather large, solitary between the plates, generally diffused, even down to the margin; a regular row between the upper and lower marginal plates and just above the lower ones. Ten primary calicinal plates of the disk are larger than the rest and distinct from them; the interradial most so. Dorsal nephridial pore distinct, surrounded by spinules.

Upper marginal plates small, irregular in form and arrangement, scarcely distinct from the abactinal plates, except close to the end of the rays, and without marginal clusters of spinules. Lower marginal plates prominent, transversely oblong, depressed, the sharp outer edge bearing a regular horizontal row of four to six rough, blunt spinules, usually four or five on the proximal and five or six on the distal ones; on the upper side of the same plates there is a secondary row of the same number of much smaller and shorter spinules.

Actinal plates evident, irregular in size and form, the smaller distal ones roundish; the more central ones elliptical, transversely elongated, and bearing about three crescentric rows of spinules; one to three bear a single, small, central spine in each area. In one specimen there are two of these spines. The adambulacral plates, near the mouth, bear a single slender inner spine, on the edge of the groove, and two stouter ones, side by side, on the actinal surface; in the middle part of the groove the spines are placed obliquely, and distally the three spines gradually come to stand nearly in a single transverse row, and they also become longer and more crowded.

Taken in the West Indies by the Blake Expedition and by the Albatross, in —— fathoms.

Family **STICHASTERIDÆ** Perrier, 1885.

Stichasteridæ Sladen, 1889, p. 430. Perrier 1894, p. 128. 1896, pp. 25–27. Verrill, 1895, p. 206.

Stephanasterias Verrill, 1871. Type, *S. albula.*

Stephanasterias Ver., Bull. Essex Inst., iii, p. 5, 1871. Expl. of Casco Bay, Proc. Am. Assoc. Adv. Sci. for 1873, pp. 356, 359, 364, 1874. Check List Invert., 1879. Expl. Albatross, 1883, p. 540, 1885.

Nanaster Perrier, Exp. Trav. et Talism., pp. 129, 131, 133, 1894. Camp. Scientif. l'Hirondelle, p. 27, 1896.

Stichaster (*pars*) Verrill, 1866, p. 351. Perrier, p. 347, 1875. Sladen, p. 432, 1889.

Perrier, in adopting this generic division, proposed by me in 1871, changed the name to *Nanaster*, on the ground that *Stephanasterias* was preoccupied by *Stephanaster* Ayres. The latter name was well known to me when I used the former, but I regard the two names as perfectly distinct: the one being based on *Asterias*; the other on *Aster*. The genus, if adopted, should therefore be called *Stephanasterias*. It is certainly very closely related to typical *Stichaster*.

The type species, *S. albula*, is common in moderately deep water (1–229 fathoms) from Greenland to Cape Hatteras. It has once been taken by the Albatross, in 1253 fathoms (station 2726, N. lat. 36° 34′), unless some mistake was made in the labelling. It has also been dredged by the U. S. Fish Commission off the coast of South Carolina and apparently in the West Indies. At least I have not yet been able to find any satisfactory characters for distinguishing the West Indian form *S. gracilis* (Per. as *Asterias*, 1884) from the northern one. It also has a wide range on the European coasts.

Note.

The specimens above described and discussed belong to several collections:

I. The general collection of the Peabody Museum, Yale University, of which I have had personal charge for many years.

II. The Museum of Comparative Zoology of Harvard University, where I have had opportunities to examine especially the collections made in the West Indies by the U. S. Coast Survey steamer "Blake," during several expeditions under the supervision of Mr. Alexander Agassiz. This collection is of particular importance for it contains the types described by Perrier, from these expeditions. My thanks are due to Mr. Walter Faxon for his kindness in affording me facilities for this study.

III. The very extensive collections made by the U. S. Fish Commission, under my supervision, from 1871 to 1887, off the north-eastern coasts of North America. A large part of this collection is now in the U. S. National Museum, but a duplicate series is in the Yale Museum.

IV. A very interesting collection of deep-sea species dredged in the West Indies and Gulf of Mexico by the U. S. Fish Comm. steamer "Albatross" in 1884–1886, and sent to me from the U. S. Nat. Museum for identification and study. This collection contains most of the new species described by Perrier, and some additional new forms.

V. A small but interesting collection made in the Bahamas and off Cuba by an expedition from the University of Iowa, and sent to me for study.

The two last named collections will be reported upon by me in detail in subsequent articles.

Much of the value of this article will be due to the unusually accurate enlarged drawings of the structural details of many of the genera and species discussed. These have all been made by my son, Mr. A. H. Verrill, and reproduced in facsimile by photolithography.

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EXPLANATION OF PLATES.

All the figures have been drawn from nature by Mr. A. H. Verrill except Plates xxiv*a* and xxv, which are from photographs.

Plate XXIV.

Figure 1.—*Mediaster Bairdii* Ver. Type. Dorsal side of the distal part of one of the rays with the granules removed. ×8.

Figure 2.—The same specimen. Group of abactinal paxillæ from the base of a ray with the spinules removed, showing the papular pores. ×8.

Figure 3.—The same. Actinal side of a ray. ×4.

Figure 4.—The same. Abactinal side of the middle portion of a ray. ×3.

Figure 5.—The same. Group of adambulacral and adjacent actinal plates. ×5.

Figure 6.—The same. Group of paxillæ and papular pores from the abactinal side of the disk. Some of the paxillæ have pedicellariæ. ×12.

Figure 7.—The same from the ray, without pedicellariæ. ×8.

Figures 8, 9.—The same. Smaller abactinal paxillæ.

Figure 10.—*Mediaster æqualis* Stimp. Actinal side of the basal part of a ray. ×6.

Figure 11.—The same specimen. Abactinal side of the basal part of a ray. ×6.

Figure 12.—The same specimen. Group of abactinal paxillæ and papular pores from the base of a ray, with granules partly removed. ×8.

Plate XXIV*a*.

Figure 1.—*Goniaster Americanus* Ver. Original type, dorsal side. From a photograph. Somewhat reduced.

Figure 2.—The same specimen. Ventral side. Somewhat reduced.

Plate XXV.

Figure 1.—*Goniaster Africanus* Ver. Original type. From a photograph. About natural size.

Figure 2.—The same specimen. Ventral side. About natural size.

Plate XXVI.

Figure 1.—*Goniaster Americanus* Ver. Original type. Group of plates of the abactinal radial areas at the base of a ray, showing the two kinds of plates, covered with granules, and the papular pores. The central plate has three spatulate pedicellariæ. Much enlarged.

Figure 2.—The same specimen. A single actinal plate having a pedicellaria (*p*) with curved blades. The blades have been removed to show the pits into which they fold when fully opened. Much enlarged.

Figure 3.—The same species. Group of abactinal plates from the central part of the disk of a smaller specimen, showing several pedicellariæ (*p*) in different positions. × about 24.

Figure 4.—The same specimen. Dorsal side of the distal part of a ray. +5½.

Figure 5.—The same specimen. Actinal side of one of the jaws and adjacent parts. ×5½.

Figure 6.—The same species. A young specimen (No. 18,459), like that described as *P. parvus* by Perrier. Dorsal surface. ×7.

Figure 7.—*Nymphaster ternalis* (Per.). Dorsal side of a part of the disk and base of a ray. The granules have been partly removed from some of the marginal plates, and entirely from some of the abactinal ones. ×5½.

Figure 8.—*Mediaster Bairdii* Ver. Part of the abactinal system of plates from the base of a ray and a part of the disk, seen from the inner side, showing the bases of the paxillæ with the radiating ossicles that connect them together, and the intervening papular pores. On the right are some of the interradial plates without papular pores between them. ×9½.

Figure 8*a*.—The same. Abactinal paxillæ from the papular region.

Plate XXVII.

Figure 1.—*Tosia* (*Plinthaster*) *nitida* Ver. Type. Dorsal view of a part of the disk and a ray. ×5½.

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Figure 2.—*Tosia* (*Plinthaster*) *compta* Ver. Type. Actinal side of the base of a ray. ×5½.

Figure 3.—*Pyrenaster dentatus* (Per.). Oral region of specimen No. 18,433. ×5½.

Figure 3*a*.—The same. Dorsal surface of one of the rays of No. 18,433. Variety with wider abactinal radial areas. ×5½.

Figure 3*b*.—The same species. A younger specimen (No. 7079). Under side of a part of the disk showing the actinal and adambulacral plates. Two of the actinal plates have a bivalve pedicellaria. ×9½.

Figure 4.—*Prionaster elegans* Ver. Type. Under side of basal part of a ray. ×5½.

Figure 4*a*.—The same specimen. One of the jaws and adjacent actinal and adambulacral plates, showing the odd interradial series of actinal plates (*m*) and the first of the paired series on each side. ×5½.

Figure 4*b*.—The same specimen. Distal part of the upper side of a ray, with the apical plate. ×7.

Figure 4*c*.—The same. One of the dorsal paxillæ. Much enlarged.

Figure 5.—*Goniopecten demonstrans* Per. Under side of part of a ray, middle portion, showing adambulacral and marginal plates in contact. ×5½.

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Figure 7.—*Blakiaster conicus* Per. Part of the actinal surface, showing two of the pedicellariæ (*p*) with spiniform blades. ×14.

Plate XXVIII.

Figure 1.—*Hippasteria Caribœa* Ver. Type. Actinal side of a part of the disk and base of a ray. ×6.

Figure 1*a*.—The same. One of the adambulacral plates, more enlarged.

Figure 2.—*Cladaster rudis* Ver. Type. Dorsal side of a part of the disk and one of the rays. ×6.

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Figure 2*b*, 2*c*.—The same. Profile views of one of the spatulate pedicellariæ, much enlarged.

Figure 3.—*Peltaster planus* Ver. Original type. Dorsal side of the distal part of a ray. ×5½.

Figure 3*a*.—The same specimen. A group of plates from the basal part of the ray; *c*, *c*, median plates. ×5½.

Figure 4.—*Peltaster hebes* Ver. Type. Actinal side of the basal part of a ray. ×5½.

Figure 5.—*Litonotaster intermedius* (Per.) Ver. Dorsal side of a ray. ×6.

Figure 5*a*.—The same. Denuded group of plates from the small papular area; *c*, *c*, median row.

Figure 5*b*.—The same. Actinal side of the base of the ray and part of disk. ×8.

Plate XXIX.

Figure 1.—*Odontaster setosus* Ver. Under side of the base of a ray and part of the disk. ×9½.

Figure 1*a*.—The same. Under side of a portion of the disk with the spinules removed to show the plates; (*m*) lower marginal plates; *b*, *b*, actinal; *a*, *a*, adambulacral plates. ×7.

Figure 1*b*.—The same. One of the jaws and adjacent parts, showing the recurved odd apical spine (*s*) of the jaw. ×9½.

Figure 1*c*.—The same. A few paxillæ from one of the basal radial areas of the upper side. ×about 5.

Figure 2.—*Odontaster setosus* Ver. Part of the interradial area of the disk with three adjacent upper marginal plates. The middle plate (*m*) is the odd interradial. ×7.

Figure 3.—*Odontaster hispidus* Ver. Part of the abactinal and upper marginal plates (*m*) at the base of a ray. The larger spines (*v*) of the lower marginal plates are also visible. ×7.

Figure 3*a*.—The same. Adambulacral plates (*a*, *a*) and spines, and first row of actinal plates (*b*, *b*). The spines have been removed from most of the plates; *f*, ambulacral furrow. ×7.

Figure 4.—*Odontaster robustus* Ver. Type. Actinal side of the base of a ray. ×9½.

Figure 4*a*.—The same. Abactinal side of a ray. ×6.

Plate XXX.

Figure 1.—*Pseudarchaster intermedius* Sla. Actinal side of a part of the disk and a ray. ×5½.

Figure 1*a*.—The same. One of the adambulacral plates more enlarged.

Figure 1*b*.—The same. Abactinal side of the basal part of a ray with most of the granules removed. ×5½.

Figure 2.—*Pseudarchaster fallax* (Per.). Abactinal side of a part of the disk and a ray, from which most of the granules have been removed. ×5½.

Figure 2*a*.—The same. One of the jaws and adjacent plates. ×5½.

Figure 2*b*.—The same. One of the abactinal paxillæ. Much enlarged.

Figure 3.—*Pseudarchaster concinnus* Ver. Type. Actinal side of the basal part of a ray, showing three pectinate fascioles (*p*). ×5½.

Figure 3*a*.—The same specimen. One of the jaws and the adjacent plates showing three pairs of pectinate fascioles. ×5½.

Figure 3*b*.—The same specimen. A group of abactinal paxillæ and papular pores from the basal radial region of a ray, including the median row (*c*, *c*). × about 6.

Figure 4.—*Pseudarchaster ordinatus* Ver. Type. Actinal side of part of the basal area of a ray and disk, showing four fascioles. ×5½.

Figure 4*a*.—The same specimen. A jaw and the adjacent parts, showing seven pectinate fascioles (*p*).

Figure 4*b*.—The same specimen. A group of abactinal plates and papular pores from the base of a ray, including the median row of plates (*c*, *c*).

Figure 5.—*Pseudarchaster hispidus* Ver. Actinal side of the basal part of a ray. ×7.

Figure 6.—*Pseudarchaster granuliferus* Ver. Type. Actinal side of a part of the disk and basal part of a ray, showing a single pectinate fasciole (*p*).

Figure 6*a*.—The same specimen. A group of abactinal paxillæ with granules removed. ×6.

Figure 7.—*Benthopecten spinosus* Ver. Abnormal specimen. One of the jaws (*j*) and interradial area, with lower marginal plates, showing a pair (*m*, *m*) in place of a single odd interradial plate. ×7.

Figure 7*a*.—The same specimen. A similar view of another jaw, having the normal odd interradial plate (*m*). ×7

Figure 8.—*Sideriaster grandis* Ver. Type. Actinal side of a part of the middle of a ray. ×4.

Figure 8*a*.—The same. One of the adambulacral plates more enlarged. ×7.

Figure 8*b*.—The same specimen. One of the abactinal paxillæ. ×5½.

Errata.

Page 146, foot note, for *planus*, read *plana*.

Page 148, line 24, for *obtusangula*, read *obtusangulus*.

Page 149, line 21, for *granularis* read *granulare*.

Page 158, line 4, for *abnormale*, read *abnormalis*.

Page 161, line 7, for *australis*, read *australe*.

V.—On the Development of the Pilidium of Certain Nemerteans. By Wesley R. Coe.

As is well known, the embryology of the nemerteans presents two distinct types of development—the indirect and the direct. In the indirect type the cleavage of the egg results in the formation of a free-swimming larva of complex structure known as the pilidium. Invaginations of the body-walls of this pilidium give rise to a young nemertean possessing the form of the adult. In the direct type there is no such differentiated larva, the segmentation of the egg resulting directly in the formation of a worm resembling the parents.

Intermediate between these two extreme types is a third form where there is a comparatively thin external, ciliated skin, inside which the young worm attains a rapid development to the adult form. Such an intermediate form is as yet known only in a single species of *Lineus* (*L. viridis* = *gesserensis*) common both on the shores of New England and in Europe. These larvæ are known as Desor's larvæ.

The *direct* type has been found to occur both in the Mesonemerteans and in Metanemerteans, and from its wide distribution we may conclude that it is common to a much greater number of species than is the indirect type. In a portion of these, however, the outer ciliated layer of ectoderm is thrown off (as in many other Platyhelminths) after a second ciliated layer has formed beneath it. This occurs in *Cephalothrix galatheæ*, according to Dieck (**11**). Bürger (**5**) is of the opinion that this is likewise true in *Prosorochmus*. In other species the outer covering of the larva, as Salensky (**27**) found in *Monopora*, passes directly into that of the adult. In only a few species of nemerteans, however, have we any knowledge whatever in regard to the embryology. Of these the development is but very superficially known in all except a half dozen species. Salensky has described the direct development of *Monopora vivipara* (**27**). The same type of development has been studied by Bürger (**5**) in *Prosorochmus*, which is likewise a viviparous species. In addition to these Lebedinsky (**20**) has recently given a detailed account of the direct mode of development in *Drepanophorus spectabilis* and *Tetrastemma vermiculus*.

Among the nemerteans of New England I have noticed that the direct type of development occurs in *Amphiporus ochraceus*, *A. virescens* and *Cephalothrix linearis*.

The *indirect* type, in which there is a pilidium formed, is known in still fewer species, and these belong to the Heteronemerteans, in most of which cephalic slits are developed. Metschnikoff (**25**) found that this type occurs in *Lineus lacteus* of Europe. There have likewise been several species of pilidium described from Europe, and three or more from America, but with one or two exceptions it has never been known to what species of nemerteans they belonged. Joh. Müller as early as 1854 (**26**) found that *Pilidium gyrans* gave rise to a young nemertean which he considered identical with *Micrura fasciolata.*

C. B. Wilson (**32**) has raised the young pilidium from the eggs of *Cerebratulus lacteus.* The young pilidium of this same species has been known to me for several years. The pilidia of *Cerebratulus leidyi* and of *Micrura cæca** may easily be reared from the eggs during the months of July and August. It is from these two species, as well as from *Cerebratulus marginatus*, from Naples, that material for the present paper has been obtained.

The deposition of the eggs and the early development of *Lineus viridis* were well described by Desor (**10**) in 1848 under the name of *Nemertes obscura.* The ciliated larva which he describes, and which represents an intermediate stage between the nemerteans with direct development and those in which a pilidium is formed, has since been known as Desor's larva. The complete embryology of this species has now become well known through the researches of M. Schultze (**29**), V. Beneden (**3**), MacIntosh (**22**), Barrois (**2**), Hubrecht (**16**), and Arnold (**1**). Bürger, in his splendid monograph on the nemerteans (**5**), gives a clear summary of both the direct and indirect types of development.

On the development of the pilidium very little has yet been published, although several authors have described more or less fully the development of the young nemertean within the pilidium. Joh. Müller in 1847 gave a good description of a pilidium which he recognized as being a larval form of some animal, and which he named *P. gyrans.* In 1854 (**26**), after further investigation, he discovered that a young nemertean developed within the pilidium. This nemertean he supposed to be the young of *M. fasciolata.* Gegenbaur in 1854 (**12**) and Krohn in 1858 (**19**) discuss further the relations of the young nemertean to the pilidium. Leuckart and Pagenstecher (**21**) describe the structure of *P. gyrans* and *P. auriculatum*, and give brief notes in regard to the development of the young nemer-

* Verrill (**31**).

tean. In 1869 Bütschli (**6**) published a further description of *P. gyrans* and gave a detailed account of the development of the nemertean. Salensky (**28**) has described very carefully the structure of the mature pilidium, and the manner in which the nemertean develops from it. His observations on the structure of the pilidium include good descriptions of the mesenchyme, the muscular system and, more particularly, of the highly developed nervous system with which he finds the embryo to be endowed. The development of the nemertean from the pilidium is also described in detail and with great clearness by Bürger (**4, 5**). Wilson (**33**), Fewkes, and others have published descriptions of several peculiar forms of pilidia. Verrill (**30**) also figures two or more species without definite descriptions. The development of the muscular system from the amœboid cells of the larval mesoderm has been described by C. B. Wilson (**32**) for *Cerebratulus lacteus*.

The only description of the development of the pilidium from the egg, however, is that given by Metschnikoff (**24, 25**) from *Lineus* (*Micrura*?) *lacteus*. The regular and equal cleavage of the egg gives rise to a typical blastula with a comparatively large segmentation cavity. The ventral cells (entoderm) soon become columnar, while those on the dorsal surface (ectoderm) remain more flattened. At the same time the cells of the whole blastula become covered with cilia, and a large flagellum appears at the upper pole. A regular invagination of the entoderm occurs after the separation from it of a few mesoderm cells. The cavity of the invaginating entoderm bends posteriorly to form the digestive canal. With the appearance of lappets the gastrula can be recognized as a pilidium. A series of infoldings of the walls of this pilidium gives rise to the body of the nemertean.

Fertilization.

A detailed account of the maturation and fertilization of the eggs of *C. marginatus* has been published recently in the Zoologischen Jahrbüchern (**8**). Soon after the egg comes in contact with the water, a pair of very minute asters appear beside the nuclear membrane, as in other eggs. Their ultimate origin was not determined. A typical polar spindle is formed, and the sixteen ring-like chromosomes divide, whether the egg has been fertilized or not. The process will go no further, however, until after fertilization, when the polar bodies are formed as usual. The first polar body occasionally divides into two. The egg is oriented even before deposition: for the asters

of the maturation spindle appear on that side of the eccentrically-placed germinal vesicle which lies nearest the surface of the egg; the polar bodies are formed on the same side; the spermatozoon usually enters at the opposite pole; and the first cleavage plane passes through the region of the polar bodies.

After the entrance of the spermatozoon its head thickens up, and a delicate aster with distinct centrosome appears in its immediate vicinity. The centrosome, and later the aster, divides into two, with the formation of a delicate spindle. The spindle is soon ruptured and the two resulting asters may remain together near the sperm-head; may separate widely from it and from each other; or one of them may wander off to a considerable distance, while the other remains in the immediate vicinity of the sperm-nucleus.

The centrosome remaining in the egg disappears after the formation of the second polar body, as do both of the sperm-asters somewhat later. The egg is thus left without visible centrosome, as commonly occurs in eggs of other animals. In this respect they agree most closely with Kostanecki and Wierzejski's account of the mollusk *Physa* (**18**), and with Child's description (**7**) of the process in the annelid *Arenicola*. The *radiations* of the sperm-asters, however, remain long after the disappearance of the centrosomes, and in most cases may be recognized even after the formation of the cleavage-asters.

From the evidence obtained from a few eggs in which the sperm-centrosomes did not disappear as soon as usual, I am of the opinion that these centrosomes do not actually end their existence with the disappearance of the sperm-asters, and that they are identical with those which later appear in the pair of cleavage-asters.

The centrosomes of the cleavage-asters are surrounded by distinct centrospheres which increase enormously in size with a very slight increase in the size of the centrosomes. These centrospheres are not artefacts, for they may be seen in the living egg. The centrosomes divide very early. In the anaphase they separate somewhat, and about each a delicate aster is formed quite within the body of the centrosphere. These little asters extend their rays outward into the reticulum of the egg and eventually form the asters of the second cleavage, somewhat as Griffin has described in *Thalassema* (**13**). Here, as in the later stages, there is certain proof of the existence of the centrosome from one cell-generation to another. Its persistence does not necessarily indicate, however, that it has any right to claim for itself a place among the essential and permanent organs of the cell.

Cleavage.

The eggs of many species of nemerteans will rarely be deposited in confinement, but will develop readily when artificially fertilized. On the southern coast of New England the eggs of *Cerebratulus lacteus* may be thus fertilized during the months of March and April; those of *C. leidyi*, *Micrura cæca*, *Cephalothrix linearis*, *Eunemertes carcinophila*, and several species of *Amphiporus* and *Tetrastemma* during July and August. The eggs of *Lineus socialis* are mature in mid-winter, and those of *L. viridis* (*gesserensis*) from February to June. At Naples an abundance of the eggs of *Cerebratulus marginatus* may be obtained in March and April. Those of the first three species, *C. lacteus*, *C. leidyi*, *M. cæca*, as well as *C. marginatus*, develop readily to pilidium-forms which are characteristic of the different species, and which will live for two weeks or more in confinement. In none of these species, however, did I find it possible to keep the pilidia alive until the development of the young nemertean.

The eggs of *C. leidyi* and *M. cæca* contain but little yolk, and are beautifully transparent. Those of *C. lacteus* and *C. marginatus*, on the other hand, contain a large quantity of yolk, are larger in size, and much less transparent. The pilidia, however, are equally transparent in all. The phenomena of cleavage and gastrulation are very similar in all four species, although the presence or absence of yolk modifies them to some extent.

It is, perhaps, advisable to follow the development in a single species and compare the others with this. Let us choose for this purpose *Micrura cæca*, the eggs of which furnish an almost ideal example of the regular, spiral type of cleavage.

The ripe egg of this nemertean measures about .09^{mm} in diameter. The vitelline membrane is extremely delicate, and can only be seen at the point where the polar bodies are formed. It is therefore very easily ruptured, and the polar bodies are lost by even a slight disturbance. The first cleavage takes place in the usual manner and divides the egg into two apparently equal cells (Fig. 1, Plate xxxi). At a temperature of 20° C. this occurs about one hour and ten minutes after fertilization. The centrosomes of the first cleavage spindle appear very early, as stated above, and the asters which are to form the spindles of the second cleavage appear even before the completion of the first cleavage (cf. 8). The first cleavage usually passes nearly through the point of extrusion of the polar bodies. A slight "*Zwischenkörper*" is formed, but this soon disappears. The two blastomeres separate widely at first and remain connected only by a

narrow bridge of protoplasm. Later they become closely pressed together (Fig. 1).

The spindles of the second cleavage occupy, as is usual, positions nearly at right angles to that of the first, and the second division is likewise vertical. The four resulting blastomeres are again almost exactly equal in size. They are also apparently similar in regard to their constituent protoplasm, for each of the four cells may be considered as being made up of one quarter of the finely granular protoplasm which was collected at the animal pole during the process of fertilization, and of one quarter of the deutoplasm which segregated towards the vegetal pole at the same time. There is no reason for believing, however, that the cells are actually alike as regards their ultimate constitution, for, as we shall see, it is probable that one of the cells has quite a different sphere of activity than any of the others. The second cleavage does not take place *exactly* at right angles to the first, so that two of the cells lie at a slightly higher level than the other two. This is one of the first indications of the spiral nature of the cleavage, which becomes so conspicuous in the later stages. In the Mollusk *Crepidula* Conklin (9) makes the very interesting observation that the obliquity of the cleavage is manifest even before the first cleavage.

Immediately after the completion of the second division the resulting blastomeres are almost perfectly spherical in form, so that they touch only on very small surfaces (Fig. 2, Pl. xxxi). Eight or ten minutes later, however, they have drawn so closely together that the surfaces of contact almost meet in the center, and leave only a very small segmentation cavity (Fig. 3). It sometimes happens that this cavity is entirely obliterated above, in which case the cells *B* and *D* commonly come in direct contact and close up the space, while *A* and *C* do not meet at all. The four cells form a nearly perfect square, one side of which is about equal to the diameter of the unsegmented egg.

When the spindles of the third cleavage are forming, each one is directed upward and somewhat to the right, showing that the third division is to be right-handed. After the separation of the eight blastomeres all are again of nearly spherical shape. The upper four are slightly, though distinctly, larger than the others,* and are more

* In *C. leidyi* and in *C. lacteus* such is likewise the case. In *Tetrastemma*, on the other hand, the upper four cells of the eight-celled stage are described by Lebedinsky (20) as being *smaller* than the lower four. In other nemerteans all of the eight cells are said to be of equal size.

widely separated from each other. Indeed, they do not usually come even in contact at first (Fig. 4). Each lies above, slightly outside, and to the right (following the hands of a watch) of its sister cell. It is interesting to note how these cells, at the time of their origin only indirectly connected, enter into the most intimate union in the later stages.

As the upper cells draw together they move so far to the right that they finally occupy positions almost, though not quite, in the intervals of the cells below (Fig. 6). This drawing together and rotation of the blastomeres of a segmenting egg is doubtless mainly due to the general physical property of surface tension. As stated by Wilson (**34**), the spiral type of cleavage "owes its peculiarities entirely to mechanical conditions, the blastomeres assuming the position of greatest economy of space, precisely like soap-bubbles or other elastic bodies." It is not unlikely that these purely physical conditions are aided by a slight mutual attraction exerted by the living protoplasm of the blastomeres.

Seen from the side (Fig. 5) the upper cells in front lie above and to the left of their sister cells. Even in the eight-celled stage there is a perceptible segmentation cavity in the center.

At the fourth cleavage the upper four cells of the eight-celled stage divide obliquely downward and to the right, while the lower four divide obliquely upward and to the left. This cleavage is therefore typically left-handed. The sixteen cells become arranged in four zones (Fig. 7), the cells of each zone forming a nearly perfect square, and alternating with those above and below.

The fifth cleavage is right-handed, the sixth left-handed, and so on, conforming to the regular spiral type. In the 16-cell stage the segmentation cavity is more than equal in diameter to one of the blastomeres, and in the later stages increases rapidly in size. In the sixth cleavage some of the thirty-two cells divide earlier than others, so that we have several distinct stages between the 32- and the 64-celled stage.

Gastrulation.

About nine hours after fertilization cilia appear on the outer surface of all the cells, and the embryo begins to swim. With the appearance of cilia a marked differentiation of the cells on the opposite sides of the blastula is noticeable, and the embryo rotates about a single axis. The rate of rotation is about two or three revolutions per second. The cells of the upper pole (corresponding with the side of

the egg where the polar bodies were extruded) become more drawn out and flattened (Fig. 1, Pl. xxxii), while those of the opposite pole become more columnar in shape and extend far inward into the segmentation cavity. The blastula flattens out and the lower half begins a regular invagination.

Before invagination, however, a few cells which are to form the larval mesoderm are separated off from the endoderm cells and make their way into the segmentation cavity (Fig. 1, Pl. xxxii). The actual origin of these cells is difficult to make out in *M. cæca*. In *C. lacteus* and *C. marginatus*, where the blastomeres are not of so nearly the same size, the origin of the mesoderm is more easily determined and will be discussed in a separate paragraph. Suffice it to say here that it *appears* to arise from two somewhat distinct, though closely connected, sources—from the divisions of a large, posterior pole cell, as in annelids, and from some of the endoderm cells. These latter seem to be indiscriminately pushed inward and set free in the segmentation cavity. It is possible that this appearance is misleading and that all of the mesoderm is actually derived from a single polar cell. The derivatives of the polar mesoderm cell always lie primarily in the lower wall of the blastula between the ectoderm and the entoderm. After the cells enter the segmentation cavity they lie upon the entoderm, and after gastrulation arrange themselves around the mouth of the gastrula (Fig. 4, Pl. xxxii).

As gastrulation proceeds the bilateral nature of the gastrula becomes very evident, not only by the arrangement of the superficial cells, but also by the marked backward inclination of the invaginating layer of entoderm (Fig. 1, Pl. xxxiii). In those species which contain but little yolk (*M. cæca, C. leidyi*) the gastrulation is perfectly regular and the entoderm-cells retain nearly the same relations with each other that they held in the blastula. Where yolk is abundant (*C. lacteus, C. marginatus*) the arrangement of the cells is broken up by the invaginating process, and they assume new positions in the enteron.

Development of the Pilidium.

By the end of the first day the cells of the dorsal surface of the embryo become much more flattened and their boundaries much less evident. Most of the yolk-globules originally contained in the cells have meanwhile been absorbed and the ectoderm becomes almost perfectly transparent. At the time of the absorption of the yolk many of the cells contain one or more large, clear vacuoles which

later disappear. By the flattening of the cells the size of the embryo is greatly increased, measuring about .11^{mm} in diameter, and the ectoderm is more widely separated from the enteron (Fig. 2, Pl. XXXIII). At the same time the ectoderm at the two lower, lateral edges of the embryo extends downward to form the side-lobes, or lappets, of the pilidium. With the further growth of the pilidium the lappets become more or less highly developed, according to the peculiarities of the particular species to which it belongs (Figs. 5, 6, Pl. XXXII).

The cells at the extreme upper pole of the embryo, instead of flattening out, become more crowded and columnar, and form the apical plate (Figs. 1, 2, Pl. XXXIII). This plate is at first covered with numerous long cilia which continue to increase in length and gradually fuse together to form a few, very long flagella. As the pilidium grows older this fusion goes on until in many cases only a single large flagellum remains.

At the end of the first day the digestive tract (Fig. 2, Pl. XXXIII) becomes differentiated into two distinct cavities—the esophagus and the intestine, the peculiarities of which will be described in detail below.

The Pilidium of Micrura cæca.

At the age of six or eight days the pilidium of this species measures about .14–.15^{mm} in length, and just about the same in a vertical direction from the apical plate to the bottom of the lappets. The pilidia usually swim near the surface of the water, with the flagellum directed upwards. A large proportion of all those contained in a vessel are usually collected in a single small space which may, or may not, be on the side of the vessel turned toward the light.

Like other pelagic embryos the pilidium is almost perfectly transparent. In general form it is balloon- or helmet-shaped with peculiarly short lappets (Fig. 6, Pl. XXXII). This pilidium differs from most other species in being of much greater diameter a short distance below the apical plate than it is on a level with the mouth. Seen from above, the outline of the body is oval or elliptical, with the longer diameter directed antero-posteriorly. The dorsal and lateral surfaces (which make up the so-called umbrellar surface) are formed from very thin five- or six-sided cells, each with a small, disk-shaped nucleus scarcely more than one-eighth the diameter of the cell. There are not usually more than sixty to eighty of these cells on the whole umbrellar surface exclusive of the lappets. Their

boundaries (Fig. 6) can be made out only after treatment with suitable reagents.

In the lappets the cells become much thicker and are correspondingly more numerous. On the free edges of these organs they are closely pressed together and become highly columnar. All the ectoderm cells are covered with cilia, the length of which corresponds more or less closely with the thickness of the cell on which they are borne. Thus the very thin cells of the dorsal surface have very short, scattered cilia, but as the columnar cells at the edges of the lappets are approached, the cilia become correspondingly longer and more closely packed together.

The apical plate is sharply marked, and is usually provided with a single flagellum nearly as long as the body. There are commonly several shorter and more slender flagella in addition to the primary one (Fig. 6, Pl. XXXII).

The mouth is highly distensible, and provided with thickened lips and buccal folds as described below. It is triangular in form and is situated slightly in front of the middle of the subumbrellar surface.

The esophagus is remarkably spacious and extends well upwards towards the apical plate. The intestine is comparatively small. It usually contains a quantity of small particles—probably food-material—which are kept in rapid motion by the long cilia lining the cavity.

The food of the pilidium probably consists of small pelagic larvæ, infusorians, diatoms, etc.—in short, of any minute organisms which can be carried into the intestine by the ciliary motion.

On the sides of the body the network of highly refractive muscular fibers with their clear nuclei are always conspicuous. They will be described in detail below.

Near the borders of the lappets and below the intestine a large number of mesenchyme cells are formed. Some of these are conspicuous from their decidedly yellowish color. Clusters of such yellowish cells doubtless correspond to the "golden-yellow spots around the margins" of the pilidium figured by Verrill (30, Fig. 6, Pl. 39). This is no evidence that the species are identical, however, for a brown or yellow color is found in such cells in several other species.

The pilidium of *C. leidyi* (Fig. 5, Pl. XXXII) differs from that described above mainly in the greater extent to which the lappets are developed in the former. In general form it is broader at the base, and not so much swollen above as in *M. cæca*. The size and general appearance otherwise are so closely similar that in certain

states of contraction it would be difficult, especially in the earlier stages, to determine to which of the two species a given individual belonged.

The pilidium of *C. lacteus* is easily distinguished from the above by its larger size and much more highly developed lappets. A detailed description of this species is promised in a forthcoming paper by Prof. C. B. Wilson, who has already published a single figure of it (32).

The Pilidium of Cerebratulus marginatus.

At Naples, in 1896, the eggs of this species could be artificially fertilized during the latter part of March and throughout the month of April. At the end of seven days the pilidium (Fig. 5, Pl. xxxv) is about .27^{mm} in length, and .21^{mm} from the apical plate to the lower edge of the moderately extended lappet. It is therefore nearly seven times as large as the pilidium of *M. cæca* or *C. leidyi* of the same age. The eggs themselves are also much larger and contain a large amount of yolk. Development is consequently much slower than in the two other species, the eggs of which contain but a small quantity of yolk. The general course of development, however, is similar in all.

The segmentation cavity in the blastula is smaller than in *M. cæca* and *C. leidyi.* Instead of being flattened, the blastula is much higher than broad* The cells on the under surface become remarkably long and encroach greatly upon the segmentation cavity (Fig. 3, Pl. xxxiii). Preparatory to invagination the entoderm cells become so closely pressed together at their lower ends that they gradually assume a conical or pear-shaped form, with their larger ends projecting far into the segmentation cavity. As the process goes on some of them become pushed inward, separated entirely from the neighboring cells, and float freely in the fluid of the segmentation cavity. They thus become mesoderm-cells, and apparently supplement the few primary mesoderm-cells which seem to have an origin similar to that of the mesoderm in the annelids.

One of these primary mesoderm-cells is seen in Fig. 3, Pl. xxxiii, *m*, in its original position at the lower, posterior border of the blastula. Three other mesoderm cells are shown in red above the entoderm. To the left of the primary mesoderm-cell are seen two very small

*The gastrula of this species is figured by Bürger (5, Figs. 1, 2, Taf. 30) from sketches by Hubrecht.

cells which apparently correspond to "posterior entoblast" cells in the annelid embryo. A further discussion of the origin of the mesoderm will be given below.

The process of invagination is somewhat different than in *M. cæca.* The pear-shaped endoderm cells near the middle of the lower surface become pressed further into the segmentation cavity so that a slight ventral depression is left (Fig. 4, Pl. XXXIII). This marks the beginning of the invagination. The individual cells slip away from the outer surface, but remain closely in contact. As those in the center pass inward they draw in their irregular, tapering, lower extremities and arrange themselves about a central cavity—the archenteron. This cavity is very narrow and communicates with the exterior by a small, circular mouth (Fig. 4). As the process goes on it becomes more like the typical invagination described above for *M. cæca.*

The intestinal canal is early differentiated into two regions as in the two species above described, and is likewise provided with a similar intestinal valve (Fig. 6, Pl. XXXIII). The esophagus remains very narrow for several days, but later becomes much enlarged. It never develops, however, to the great extent characteristic for the two other species. Buccal folds are present as thickenings of the posterior esophagal walls.

The muscular system develops as in the other species, and is arranged in much the same way. The lateral bands to the lappets consist of more numerous fibers which are not so regularly arranged. The two bundles running from the apical plate to the anterior border of the esophagus are well marked in this species.

During the formation of the gastrula the ectoderm becomes very thin, and the apical plate forms as in *M. cæca.* There is usually but a single flagellum. This is nearly as long as the body.

The mesenchyme cells are several times more numerous and larger than in the other species, but have the same general arrangement (Figs. 3–6, Pl. XXXIII). Some of those which find their way into the lappets later acquire a reddish tinge. There is also a slightly reddish tinge to the marginal cells of the lappets.

This may, perhaps, be looked upon as an indication that this pilidium possibly develops into the *Pilidium gyrans* of Müller. The time of the year when both may be found probably agrees. Moreover the geographical distribution of *P. gyrans* corresponds more or less closely with that of *C. marginatus.* The great abundance of *C. marginatus*, and the enormous number of eggs produced, makes the chances of obtaining pilidia of this particular species greater than is the case with almost any other species.

The Digestive Tract.

At the end of twenty-four hours the wall of the enteron in *M. cæca* and *C. leidyi* becomes divided into two distinct regions—an anterior, buccal cavity, or esophagus, composed of flattened cells, and a posterior blind sack, or intestine, of columnar cells provided with very long cilia (Fig. 2, Pl. xxxiii ; Fig. 1, Pl. xxxiv). Later cell-processes grow out to form a sort of intestinal valve which separates the two cavities completely. These processes (Fig. 3, Pl. xxxiv) are produced by the half-dozen cells which lie immediately between the two cavities. They are devoid of cilia, and closely resemble the blunt pseudopodia of an amœba. Ordinarily they meet in the center, so that the two cavities of the digestive tract are not in direct communication.

The cells of the valve do not actually fuse together, however, as may be seen by placing a little finely powdered carmine in the water with the embryos. The particles of the carmine are readily taken into the mouth and collected at the posterior end of the esophagus. Here they are churned round and round against the intestinal valve. When a considerable quantity has been collected, the pseudopod-like ends of the cells forming the valve separate, as in a true sphincter, and the carmine passes into the intestine. There it is rapidly revolved for a time by the motions of the long cilia lining the cavity.

Hubrecht (**16**) and Arnold (**1**) find in Desor's larva that at a certain stage in the development the esophagus is for a long time completely cut off from communication with the intestine by a solid growth of cells. At a later period these cells separate, and communication is again established. It seems probable that this mass of cells is represented in the pilidium in a rudimentary way by the amœboid cell-processes of the intestinal valve.

Eventually the particles of carmine, or of undigested food-material, are thrown out of the mouth, but not at the same region where they entered ; for these particles always enter at the anterior end of the mouth and leave at the posterior.

The mechanism by which the in-coming is separated from the outgoing current consists of a thickened fold of large cells covered with especially strong cilia. This fold, which we may call the buccal ridge, extends forwards and downwards on each side (Fig. 3, Pl. xxxiv; Fig. 1, Pl. xxxv, *a*) to the border of the mouth-opening, where it is continuous with the lateral lips.

These oblique folds, which are so greatly developed in *M. cæca* and *C. leidyi*, are represented in *C. lacteus* and *marginatus* only by slight thickenings of the posterior wall of the buccal cavity.

During the first two days only a few particles of powdered carmine will be ingested, but after this time it is devoured in large quantities.

The *mouth* of the pilidium develops directly out of the gastrula-mouth, although the true blastopore is pushed inward and marks the opening of the esophagus into the intestine. In the early gastrula the opening becomes oval, and this shape is retained in the pilidium.

On the sides of the mouth the epithelium of the esophagus is separated from that of the under surface of the pilidium by a pair of thickened folds, or lips (Fig. 2, Pl. xxxiv), covered with especially strong cilia. These lips are united in front, but are widely separated posteriorly and become continuous with the pair of buccal ridges which reach inwards towards the intestine. The relation of these parts is well shown in Fig. 3, Pl. xxxiv. In this figure one of the lips is seen between the lines converging at *m*, and represents the extent of the mouth proper. It is only between these lips that water or food-particles can enter the esophagus. The lip is continued posteriorly into the buccal ridge, *a*, which finally becomes lost in the wall of the esophagus. It is between the two buccal ridges that water with substances in suspension passes out from the esophagus to the exterior.

In Fig. 1, Pl. xxxiv, which represents an earlier stage, no such buccal folds are present, and consequently there is no definite current of water passing through the esophagus. At this stage very few, if any, particles of carmine are taken into the digestive canal.

When the buccal ridges have become established, a current of water carrying food-particles, etc. is constantly passing into the esophagus through the mouth proper, and out again between the posterior buccal ridges. In passing through the esophagus the solid material is collected by the cilia and passed into the intestine, as was described above.

The esophagus of the pilidium is found by Salensky (**28**), Butschli (**6**), and others to develop directly into the esophagus of the adult nemertean. Likewise from the intestine the corresponding part of the adult nemertean develops. Hubrecht (**16**) finds that this is likewise true of Desor's larva. He also considers the esophagus to be composed of entoderm, and that the blastopore becomes the mouth of the nemertean. Arnold (**1**), on the other hand, believes that the esophagus is formed by an invagination of "secondary" ectoderm, by which the blastopore is pushed inward and is repre-

sented by the opening of the esophagus into the intestine. This becomes closed for a long time, as found by Hubrecht.

In the nemerteans with direct development, both the esophagus and the rectum are formed by special invaginations of the ectoderm, and are both widely separated from the blastopore.

The development of the intestinal tract in the pilidium, however, offers little positive evidence as to whether the esophagus is ectodermic in origin, because in this form the whole digestive tract (except the rectum) is formed by an almost continuous invagination. From a comparison with other forms, as well as from the histological peculiarities of the esophagus of the adult nemertean, it seems highly probable, as urged by Bürger in his splendid monograph, that this organ is here likewise of an ectodermic origin. A strong point in favor of this is the fact that the intestinal valve is indicated at a very early period. The histological differences likewise manifest themselves very early. As Bürger also states, such a supposition is necessary in order that the nephridial invaginations in different groups of nemerteans may not appear to originate in different layers of the body.

We may thus conclude that the process of invagination involves not only all of the entoderm cells on the lower pole of the blastula, but also some of the surrounding ectoderm cells by a continuous process of infolding. The blastopore would be pushed inward, and would be marked by the intestinal valve, or an homologous thickening of the epithelium.

The whole digestive tract is capable of movement to a considerable extent independent of that of the body-walls. In life the form of its parts, especially of the esophagus, is continually changing. This movement, which is sometimes vigorous, is accomplished by the contraction of the fibers of the few muscular cells which lie directly beneath the epithelium of the digestive canal, and of other fibers which connect this canal with the other parts of the body.

Histologically the two portions of the digestive tract show marked differences in structure. Both in *M. cæca* and in *C. leidyi* the *esophagus* is very large (Fig. 3, Pl. xxxiv) and is bordered by extremely thin epithelium. In the earlier stages of the pilidium the cells of the esophagus were as large as those of the intestine. The esophagus later increases to several times its original size without any increase whatever in the number of cells composing it, so that each cell must cover a large surface and becomes correspondingly thin. In *C. marginatus* (Fig. 6, Pl. xxxiii) and also in *C. lacteus*

the esophagus is comparatively much smaller and its epithelium is correspondingly thicker.

The cilia on the esophagal cells are for the most part short and scattered. Near the intestine the cells become much thicker and the cilia longer and more numerous.

The cells making up the blind *intestinal sack* are always more or less columnar in form, and all are provided with very long and strong cilia. By means of these any food-particles which may pass into the intestine are churned rapidly round and round. In *M. cæca* and *C. leidyi* the intestinal cells are more highly columnar in the earlier stages (Fig. 2, Pl. XXXIII) than in the later (Fig. 3, Pl. XXXIV). In *C. marginatus* (Fig. 6, Pl. XXXIII) and in *C. lacteus* the cells are much more elongated, and their oval nuclei comparatively smaller than in the other two species.

In that portion of the cell which lies nearest the lumen of the intestine are often found numerous small granules, and sometimes, vacuoles of secretion (Fig. 1, Pl. XXXV). This secretion is doubtless a special digestive fluid which is poured out into the canal when food is present. In *C. marginatus* such granules or vacuoles often appear even before the pilidium is fully formed.

In many specimens we find that a few of the intestinal cells stain quite differently than most of the others. Two of these cells are shown in Fig. 6, Pl. XXXIII. Their protoplasm is more granular and is also vacuolated. They have likewise a much greater affinity for stains. Both Salensky (28) and Bürger (5) describe such cells. The former suggests that they may be specialized cells of the nervous system, while Bürger considers them to be differentiated gland-cells. There is little doubt that the latter view is correct, especially as the contents of the cells often resemble very closely those of some of the gland-cells in the intestine of the adult.

The Apical Plate.

In the course of gastrulation, when the cells of the upper surface of the body begin to flatten out, it is observed that a small cluster of cells at the very apex do not take part in the flattening process, but retain their columnar shape. These furnish the "*Anlage*" of the future apical plate. The cells divide longitudinally and thereby become much smaller than the neighboring cells, although they remain as long or longer than at first. They thus become highly columnar, and are conspicuous in sections, because of their less granular protoplasm, which shows a special affinity for stains (Fig. 4, Pl.

XXXII). Their position is also marked by the depression, or circular pit, which eventually appears at this point. This pit seems to be well developed in all species of pilidia. In general it increases in depth with the increase in age of the individual. It is thus very much deeper in mature pilidia found free in the water than in the young specimens raised in the aquarium.

After the formation of the muscular system strong fibers pass directly from the apical plate to the anterior, lower borders of the body and to the esophagus. By the contraction of these muscles the pit is deepened, and the plate is withdrawn far below the general surface of the body. The movement of the flagellum is probably also aided by these muscles.

The cilia are longer on the apical plate than elsewhere on the body, and some of them increase so much in size that they come to be recognized as flagella. The number of such flagella is at first considerable (Figs. 1, 2, Pl. XXXIII), but they rapidly fuse together to such an extent that only a few are present in the early pilidium (Fig. 1, Pl. XXXIV). These increase in length until they become half as long as the diameter of the body. Fusion goes on as the pilidium increases in size. At the age of three or four days the number has diminished to one or two long, whip-like flagella with several shorter ones (Figs. 5, 6, Pl. XXXII; Figs. 2, 3, Pl. XXXIV). It usually happens that these eventually fuse together, and the pilidium is provided with a single, thickened flagellum, the length of which is in *M. cæca* and *C. leidyi* about equal to that of the body.

When but a single flagellum is present its compound nature can be recognized at the point where it spreads out on the cells of the apical plate, for a considerable number of cells furnish it support. Bütschli (**6**) was the first to recognize that the flagellum was a consolidation of several more slender ones. Aceto-carmine often serves to separate the original constituents.

In *C. marginatus* there is usually but a single flagellum as early as the gastrular stage. In addition to this several rudimentary ones may be present (Fig. 6, Pl. XXXIII; Fig. 5, Pl. XXXV). Wilson figures (**32**) several flagella for the pilidium of *C. lacteus*. I think a single one, however, is much more common in all stages after the gastrula.

It occasionally happens that the flagella of the apical plate are arranged in two distinct clusters, as Wilson shows in his figure of *C. lacteus*. Likewise the apical plate itself may be divided into two. In a few instances two distinct and widely separated plates were present—one at the apex as usual, and the other about half way

between this one and the lower border of the pilidium. Both were fully developed, and a distinct set of muscular fibers ran from each of them to the lappets. All such cases must, of course, be looked upon as abnormalities.

Salensky mentions (28) that some of the cells of the apical plate are continued internally into slender processes which he considers to be nerve-fibers. I was quite unable to distinguish any such nerve-fibers from the numerous muscle-fibers which have their centers of attachment among the cells of the plate. The relations of the cells of the plate with these muscular fibers and the cells of which they are outgrowths are shown in Fig. 6, Pl. xxxv. As will be seen from the figure the muscle-fibers do not come off directly from the plate-cells themselves, but rather they are fastened into the intercellular cementing substance. Whether Salensky mistook these fibers for nerve-fibers it is impossible to decide.

Both from its position and general appearance the apical plate of the pilidium is naturally looked upon as homologous with that of the trochophore-larva of Annelids. In both groups this plate usually bears a tuft of long cilia or a single flagellum. From it muscles run similarly to the digestive tract and to the sides of the body. This organ in the trochophore, as is well known, represents the "*Anlage*" of the superior esophagal ganglion of the adult. The sensory nature of this plate in the pilidium has, for these reasons, been generally conceded. On this account it is very disappointing to be unable to find (by the use of methylene blue, or otherwise) any trace of differentiated nervous structures in the young pilidia under consideration.

The Lappets.

At the end of the first day the ectoderm of the lower, lateral edges of the embryo becomes extended to form the side-lobes, or lappets, of the pilidium. These increase in size very slowly in *M. cæca* and *C. leidyi*, and at the end of two weeks are, in comparison with those of many other species, only slightly developed (Fig. 6, Pl. xxxii). It seems probable that this rudimentary condition of the lappets remains thoughout the life of the pilidium, since they are here decidedly longer than those described for the mature *Pilidium auriculatum* of Europe.

In *C. leidyi* the lappets are developed to a greater extent than in *M. cæca*, as is seen from a comparison of Figs. 5 and 6, Pl. xxxii.*

* It should be noted that the magnification of the two figures in not the same. The pilidia of both species are of nearly equal size.

In *C. marginatus* (Fig. 5, Pl. xxxv), these organs develop much more rapidly and to a much greater extent. Their size is still greater in *C. lacteus*, as may be seen from Wilson's figure (**32**).

Their epithelial cells are thicker and correspondingly more numerous than over the rest of the body. The free edge of each lappet is thickened and covered with especially strong cilia.

The muscular system is more highly developed here than in any other part of the body excepting that immediately surrounding the apical plate. In life the shape of the lobes is continually changing, and violent contractions are not infrequently observed. The distribution of the muscular fibers will be described below. In the optical sections shown in Figs. 2 and 4, Pl. xxxiv, the relations of the muscular cells and fibers to the epithelium are indicated.

Besides the cells and fibers of the muscular system the cavity of the lappets contains a considerable number of mesenchyme cells freely suspended in the slightly gelatinous fluid which fills the whole cavity of the body. These mesenchyme cells are irregular in form, sometimes showing amœboid movements, and are often conspicuous from their yellowish or brownish color.

The Nervous System.

Salensky (**28**) has described for the pilidium a highly developed and complex system of nerve-cells and nerve-fibers. The nervous structures develop, as does the muscular system, out of the amœboid cells of the larval mesenchyme. Both bipolar and multipolar cells are said to be present, and are provided with numerous, branching processes.

Salensky considers that the cells of the apical plate are highly sensory, and finds that many of them are continued internally into very fine nerve-fibers. These run in company with the muscular fibers to the anterior border of the esophagus and to the lappets. He likewise finds a band of nerve-cells and nerve-fibers, constituting what he calls a nerve-ring, reaching completely around the margins of the pilidium and extending to the borders of the lappets. At the anterior, upper border of each lappet he finds a ganglionated swelling in the nerve-ring. This he considers the central organ of the nervous system. Finally, he considers that some of the cells lining the intestine belong to the category of nerve-cells.

These last-mentioned are obviously nothing but glandular cells which are partially filled with a deeply-staining secretion, as de-

scribed above, and have no sensory function whatever. On the nature of the other nervous structures which Salensky describes the pilidia here recorded throw no light whatever. In no case was I able to demonstrate that any supposedly nervous elements did not actually belong to the muscular system. In this respect my results agree with those of others who have worked upon similar pelagic embryos of other groups.

The Larval Mesenchyme.

The mesodermic structures of the pilidium are of two sorts, but the cells from which they arise are at first indistinguishable from each other. They later become widely different and form the muscular system, described below, and the larval mesenchyme. The mesenchyme cells float freely about in the body-cavity and doubtless secrete a small quantity of transparent, gelatinous substance which, with a large amount of water, fills up the whole cavity.

The cells of the mesenchyme have already been well described by Metschnikoff (**25**), Salensky (**28**), C. B. Wilson (**32**) and others. It is from these cells that the musculature of the adult nemertean develops. Hubrecht (**16**) states that in Desor's larva the adult nervous system is also derived from the larval mesenchyme. Bürger, on the other hand, feels confident that such is not actually the case, but that in Desor's larva, as in the pilidium, the nervous system arises directly from the ectoderm (**5**, p. 475). The development of the muscle-cells of the pilidium from the undifferentiated amœboid cells of the mesoderm has recently been described by C. B. Wilson.*

Some of the mesenchyme cells become collected in clusters near the edge of the lappets and below the intestine. These often contain a number of clear vacuoles the contents of which perhaps contribute to the formation of the transparent, jelly-like substance which fills the whole body. Others are equally conspicuous because of their decidedly yellowish color. They are, on the whole, not very different from the original mesoderm cells. They are oval or amœboid in shape, and are much larger than the muscle-cells. They have little to do with the formation of the pilidium and are held in reserve until the body of the young nemertean begins to develop.

* It is doubtless due to a typographical error that Wilson (**32**, p. 20) states that "the mesenchyme first appears as isolated cells derived from the *ectoderm*, as observed by Metschnikoff." Metschnikoff (**25**, p. 53) says that they almost certainly arise from the *entoderm*.

The Muscular System.

In the living pilidium the muscles appear as clear, highly refractive fibers, which are most commonly slightly curved. In optical cross-section each fiber appears as a bright dot. They run in a more or less irregular course from the muscle-cells to their attachment in the epithelium, or to an anastomosis with another fiber. When the embryo is killed they contract forcibly, thereby reducing greatly its size. This is in part accomplished by forcing water out of the digestive canal.

In contracting the fiber not only shortens in length, but also becomes wavy and twisted upon itself, or coiled up in a spiral like the stem of a Vorticella. Fig. 3, Pl. xxxv, shows the fibers in a living pilidium, while Fig. 5, Pl. xxxiv represents similar fibers after the embryo has been killed with corrosive sublimate.

The nuclei of the muscle-cells are mostly clear, oval bodies about .003^{mm} in length. Around the nucleus is a very small quantity of perfectly clear protoplasm, from which two, three, or more contractile fibers extend in various directions.

The origin of the muscles from undifferentiated mesenchyme is easily followed because of the transparency of the embryos. The cells of the mesenchyme, as stated above, appear in the segmentation cavity in the earliest stages of gastrulation. Some of them seem to originate directly from the entoderm, while others are derived from a pair of primary mesoderm cells set apart as such in the blastula. Never have I seen any indication that any of them came from the ectoderm, as Hubrecht (**16**) describes in Desor's larva.*

At the time of their first appearance the mesenchyme cells are very large and few in number. During gastrulation they multiply rapidly, as may be seen from the many karyokinetic figures which they contain. At the time of appearance of the lappets which distinguish the pilidium from the gastrula their number is very considerable. Some of them become irregular in shape, as described by Metschnikoff (**25**), and as Wilson (**32**) has pointed out in *C. lacteus*. If watched carefully, some of these irregular cells will be seen to send out amœboid processes, and exhibit a great deal of independent motion. They not only change their shape, but actually move about in the cavity of the body by means of their pseudopod-like processes.

* Arnold (1) has recently reinvestigated the development of Desor's larva, and finds that the mesoderm originates on both sides of the blastopore at the point where entoderm and ectoderm come together.

They later collect in more or less constant numbers in certain definite localities, where they send out especially long processes and attach themselves permanently to the epithelium. When they are no longer freely movable in the segmentation cavity their processes grow out into long fibers. They are then recognized as muscle-elements. In the early pilidium we find a dozen or more such cells immediately beneath the apical plate. Others fasten themselves firmly to the walls of the body and to the digestive tract, and a considerable number to the lower borders of the lappets.

Fibers now grow out in certain definite directions. At the end of two or three days, they have elongated and anastomosed with each other to such an extent that they form a practically continuous system of interdependent muscles. Some of these eventually become arranged in several definite muscular bands, while others form an irregular network connecting these bands, as Salensky (28), Bütschli (6), and Wilson (32) have described for other species. The musculature in *M. cœca* and *C. leidyi* consists (*a*) of two principal muscular bands extending from the apical plate to the two lappets; (*b*) of a pair of bands extending longitudinally along the floor of the pilidium at the sides of the mouth; (*c*) of a few fibers connecting the apical plate with the anterior border of the esophagus; (*d*) of a few fibers with numerous branches lying on the anterior and posterior faces of the embryo; (*e*) of a few surrounding the digestive tract and serving to connect this organ with the body-walls.

Of these bands the lateral pair connecting the apical plate with the lappets is by far the most extensive. In close proximity to the crowded, columnar cells of the apical plate lie about six or eight muscle-cells on each side. From each of these cells proceed one or two long, slender, branched fibers which pass close beneath the body-epithelium downwards until they either anastomose with fibers from similar cells in the lappets or become attached directly among the epithelial cells at the lower margin of these lobes (Fig. 2, Pl. xxxiv; Fig. 3, Pl. xxxv). One or two other fibers from each cell pass among the columnar cells of the plate and serve to anchor the muscle-cell in place. From the dorsal surface the arrangement of these cells and fibers is shown in Fig. 2, Pl. xxxv. Those fibers running nearly parallel down the right and left sides constitute the lateral bands.

The muscle-cells in the lappets send similar processes toward the apical plate. These, in part, anastomose with the fibers from the apical plate. Thus there are from eight to sixteen fibers running

more or less parallel between the apical plate and the lower borders of the lappets. The cells in the lappets likewise send off longitudinal fibers along the floor of the lobe, as well as towards the borders of the mouth. This complex system of muscles enables the lappets to be moved readily in any direction.

Figure 3, Pl. xxxv, represents somewhat diagrammatically the arrangement of the muscle-cells and fibers which are seen in a side view of a pilidium. The nearly parallel vertical fibers constitute one of the lateral muscle-bands. The relation of the muscle-cells to the cells of the apical plate is shown in Fig. 6, Pl. xxxv. As seen in the figure, the muscular fibers are attached between the epithelial cells rather than directly to their faces. Likewise the arrangement of the muscle-cells and mesenchyme-cells in the lappets, and the relation of the fibers to the epithelial cells is shown in Fig. 4, Pl. xxxiv.

On the anterior and posterior faces of the pilidium we find comparatively few fibers, and these are much branched. They run mostly horizontally or obliquely instead of vertically, as on the lateral faces. They anastomose freely with each other, with the fibers from the apical plate, and with others passing inward to the digestive canal. Those on the anterior face are represented in Fig. 4, Pl. xxxv.

In the mature pilidium one of the largest and most conspicuous muscle-bundles is that running from the apical plate to each side of the anterior border of the esophagus and thence to the lappet. This muscle is well developed in *C. marginatus*, where it consists of several strong fibers. It is represented in *C. leidyi* and *M. cæca* merely by a very few delicate and widely separated fibers. Two of these fibers are represented in Fig. 3, Pl. xxxiv. They serve both to hold the esophagus in place and to withdraw the apical plate. They doubtless also aid in rocking the plate and thus moving the flagellum.

From the region of the mouth a series of scattered muscular fibers runs radially in all directions. A few are fastened to the anterior and posterior margins of the body, but most of them pass into the lappets, at the edges of which they are attached. Besides these there is a horizontal bundle running longitudinally along the floor of the body-cavity on each side of the mouth. One of these muscle-bands is represented in dotted lines in Fig. 3, Pl. xxxv, (*b*). Their fibers are fastened at the anterior and posterior margins of the body, and anastomose freely with other fibers.

Surrounding the whole alimentary canal and connected with the other muscular bands by frequent anastomoses is an irregular network of scattered fibers which provide this organ with independent motion and also serve to hold it in place.

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EXPLANATION OF PLATES.

Plate XXXI.

Early cleavage of the egg of *Micrura cæca*. Camera lucida drawings of living eggs at a magnification of about 300 diameters.

Figure 1.—Egg about one hour and forty minutes after fertilization. The fully formed spindles of the second cleavage are indicated by dotted lines. Above are the two polar bodies.

Figure 2.—The same egg eight minutes later. The spindles are still evident. The polar bodies lie between the blastomeres.

Figure 3.—The same egg after fifteen minutes more. The blastomeres have drawn very closely together, leaving but a minute cavity between them. 1, 1, denote the plane of the first cleavage; 2, 2, that of the second cleavage. *A*, *B*, *C*, *D*, the four quadrants of the egg. One of the asters of the third cleavage is seen in each blastomere.

Figure 4.—The third cleavage just completed. The upper four cells are widely separated. Each lies somewhat outside and to the right (following the hands of a watch) of its sister-cell.

Figure 5.—Eight-celled stage from the side. The first polar body lies above. 3, 3, denote the plane of the third cleavage.

Figure 6.—Eight-celled stage from above after the blastomeres have drawn together. Same position as fig. 3. Polar bodies are not shown.

Figure 7.—Sixteen-celled stage from above. In the same position as fig. 3.

Figure 8.—The same stage from the side.

Plate XXXII.

The mesoderm cells are indicated in red.

Figure 1.—Vertical section of the blastula of *Micrura cæca*, nine hours after fertilization of the egg. The two large cells (one of which is in the process of division) within the segmentation cavity are mesoderm cells. × 600.

Figure 2.—Horizontal section of the gastrula of *M. cæca*, at a stage somewhat later than that shown in fig. 3. The section passes along a plane at a level with *x*, *x*, fig. 1, Pl. XXXIII. The circle of ciliated cells in the center represents a section of the entodermic sack. In the space between the entoderm and ectoderm are seen several cells of the larval mesoderm. These cells are now much smaller and more numerous than in fig. 1. × 600.

Figure 3.—A gastrula of *M. cæca*, seventeen hours after fertilization. The dark ring in the center indicates the blastopore. The cell-boundaries and the nuclei are drawn as accurately as possible from an egg fixed in picro-acetic, stained with acidulated hæmatoxylin and mounted in oil of cloves. The anterior surface is towards the top of the page. Cilia are not indicated. × 600.

Figure 4.—Vertical section of the gastrula of *C. leidyi*, seventeen hours after fertilization. The apical plate is indicated by darker stipple. The mesoderm-cells lie at the sides of the entodermic invagination. The segmentation cavity is smaller than normal owing to the shrinkage which took place during the process of imbedding in paraffin. One of the endoderm cells is dividing vertically. × 500.

Figure 5.—A pilidium of *C. leidyi* at the age of ten days. The dotted lines indicate the position and thickness of the walls of the enteric cavity; *o*, cavity of esophagus; *i*, cavity of intestine. × 250.

Figure 6.—Pilidium of *M. cæca* at the eighth day. The nuclei on the surface are those of the ectoderm cells, the boundaries of which are indicated by faint, dotted lines. The coarse, dotted line indicates the position of the enteron, as in fig. 5. The mouth is indicated by the heaviest dotted line (cf. Pl. XXXIV, fig. 3). Below the mouth is seen one of the very short lappets with its strong cilia and numerous nuclei. × 400.

Plate XXXIII.

In all the figures the cells of the larval mesoderm are indicated in red.

Figure 1.—Median, optical, sagittal section of gastrula of *M. cæca* fifteen hours after fertilization. The cells of the apical plate with their developing flagella are indicated by the darker stipple. The cilia, which cover the whole surface, are not shown. × 600. Corrosive sublimate, acidulated hæmatoxylin.

Figure 2.—A similar section of the very early pilidium of *M. cæca* twenty-four hours after fertilization. Below the section is a line which indicates the extent to which the lappets have developed. The boundaries of the cells are merely indicated. Slightly diagrammatic. × 600.

Figure 3.—Median vertical section of blastula of *C. marginatus*. At the right of the elongated entoderm cells is a larger cell, *m*, in process of division. This cell appears to be homologous with one of the primary mesoblast cells of the annelid embryo. Immediately to the left of *m* are two minute cells which bear a striking resemblance to the annelid "posterior entoblast" cells. Picro-acetic. × 350.

Figure 4.—Early gastrula of *C. marginatus*. The cells of the apical plate are indicated by darker stipple. The blastopore is very narrow. The entoderm cells have not yet become arranged to form the intestinal canal. Picro-acetic. × 300.

Figure 5.—Median, sagittal section of late gastrula of *C. marginatus*. Picro-acetic. × 350.

Figure 6.—Median, sagittal section of the embryo of *C. marginatus* at the beginning of the pilidium-stage. The extent of the lappets is indicated by the line (with cilia) below the section. On the dorsal side the section must be considered as being of great thickness, for the drawing represents not only a section of the apical plate, but also a surface view of half of the depression above it from which the flagellum issues. The two darker cells in the intestinal wall are gland-cells. The intestinal sphincter (devoid of cilia) is partially contracted. Slightly diagrammatic. Picro-acetic. × 350.

Plate XXXIV.

The mesodermic structures are printed in red.

Figure 1.—Optical, median, sagittal section of the early pilidium of *C. leidyi*, thirty-six hours after fertilization. To the section the right lappet has been added, and likewise the right half of the apical depression. The nuclei and cell-boundaries have been drawn from an actual section. The mesoderm cells are arranging themselves in their definite positions. × 375.

Figure 2.—Optical, transverse section of the pilidium of *M. cæca* at the age of ten days. The section passes through the mouth, esophagus and apical plate (cf. fig. 3). Below the esophagus are sections of the two horizontal lips (*l*) with strong cilia bordering the mouth. The lappets are contracted, and therefore thicker than in life. Just inside the epithelium (both of the ectoderm and entoderm) are drawn in red the cells and fibers of the larval musculature. The larger, dotted, red cells are those of the mesenchyme. The single, coarse flagellum is seen to be made up by the consolidation of several more slender flagella. The mesoderm cells are grouped mostly in the lappets, and just beneath the apical plate. × 500.

Figure 3.—The left half of a pilidium of *M. cæca* of ten days. A median, sagittal section is represented in stipple. In addition to this the left buccal ridge (*a*) is shown in surface view at a lower level. This buccal ridge is seen to be continuous with the left lip at the border of the mouth. Below the lip the short lappet is shown somewhat contracted. The mouth is widely opened and extends horizontally between the lines converging at *m*. The intestinal sphincter is partially contracted. The mesodermic structures are indicated as in fig. 2. Two mesenchyme cells with amœboid processes lie above the digestive canal, and several others without processes lie beneath the intestine. × 500.

Figure 4.—Transverse section of a lappet more highly magnified to show the relation of the mesodermic structures to the ectoderm-cells. Three muscle-cells are shown with their fibrous processes inserted between the epithelial cells. Near the angle of the lappet a single, rounded mesenchyme cell is represented. The letter *b* indicates the ectoderm of the lateral surface of the body; *c*, that of the under surface.

Figure 5.—Five partially developed muscle-cells with contracted processes after killing with corrosive sublimate.

Plate XXXV.

The mesoderm is printed in red.

Figure 1.—Median, sagittal section of the pilidium of *M. cæca* at the end of the third day. This is a much earlier stage than that shown in fig. 3, Pl. xxxi. The muscular cells have attached themselves in their definite positions, and have already begun to send out fibrous contractile processes. Not all of the mesenchyme-cells are distinguishable from the muscle-cells. The outline of the lappet is indicated beneath the section. One of the buccal ridges (*a*) is indicated, as is also the extent of the mouth (*m*). × 500.

Figure 2.—Dorsal view of pilidium of *M. cæca* at the age of twelve days. In the center are the cells of the apical plate (black) with two large flagella directed upwards. To the right and left of the apical plate are seven or eight muscle-cells with their fibers running down the sides of the body towards the lappets. These fibers constitute the lateral muscular band. In front and behind the apical plate the muscle-cells are few in number, and repeatedly anastomose. The ectoderm is not shown; *a*, anterior, *p*, posterior end. Slightly diagrammatic. × 500.

Figure 3.—Pilidium of *M. cæca* at the age of twelve days seen from the left side. The epithelium is supposed to be transparent except at the margins of the drawing, where it is shown in section to illustrate its thickness; *a*, anterior end, *p*, posterior end. At the side of the apical plate are seen six muscle-cells with nearly parallel fibers running directly into the lappet. These lie immediately beneath the surface epithelium, and constitute the lateral muscular band. A few cells on the lateral face of the embryo send out anastomosing fibers in all directions. The horizontal band of muscles, indicated by the dotted lines (*b*), are those which run antero-posteriorly at the sides of the mouth. Three mesenchyme cells are indicated by *c*, while a half-dozen others are seen between the muscle-cells in the lappets. Slightly diagrammatic. The number and position of the muscle-cells and fibers was confirmed in the living object, and also in many stained preparations. × 500.

Figure 4.—An anterior view of a pilidium of the same age as those in figs. 2 and 3.

Figure 5.—Pilidium of *C. marginatus* at the age of ten days. The dotted lines indicate the digestive tract.

Figure 6.—Section through the apical plate to show the relation of the muscle-cells to the epithelium.

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VI.—The Maturation, Fertilization and Early Development of the Planarians. By Willard G. VanName.

Illustrated by plates XXXVI to XLI inclusive.

The eggs of some species of planarians, particularly those of some of the polyclads, offer many advantages for the study of the processes of maturation and fertilization. The ease with which many of these animals may be kept in captivity, and the abundance of eggs which they produce when kept under the right conditions, make the material easy to obtain if the adult animals can be secured at the proper season, while the fact that the eggs are fertilized within the body of the adult protects them from the unnatural conditions which so often produce abnormalities and pathological changes in eggs artificially fertilized.

There are, however, difficulties in the way of preserving these eggs which make good preparations not easy to obtain. The membrane enclosing the egg is very thick and is penetrated by preserving fluids with difficulty. In addition to this they are in many cases thickly coated with mucus, which is coagulated by the reagent and offers much resistance to its penetration. These envelopes of the eggs are also apt to cause trouble in imbedding and in cutting sections.

The consequence has been that although the eggs of a number of species of planarians have been studied by different investigators, there is uncertainty and disagreement in regard to many points which can hardly be due to essential differences between the species studied, since with one exception they were all polyclads, as are also the two which are the subject of the present paper.

Mitotic figures were observed in the eggs of planarians by Selenka (21) and Lang (18) many years ago and a series of short papers was published by Van der Stricht (22 to 27 inclusive) on the egg of *Thysanozoon Brocchi*, but the principal contributions to our knowledge of the subject have appeared within the last two or three years. These are the work of Klinckowström (14) on the egg of *Prosthecerœus vittatus*, the two papers of Francotte (3, 4) describing and illustrating those of the same and several other polyclads, and a later work of Van der Stricht (28) on the egg of *Thysanozoon*. The investigations of the two last mentioned writers especially have done a great deal to clear up the doubtful points and bring our ideas of

the development of the planarian egg into line with the observations on those of animals of other classes.

But as I have been so fortunate as to obtain some unusually good preparations of polyclad eggs, a description of them may be of interest not only on account of the additional light it may throw on the points left unsettled or passed over briefly by the previous writers, but also as confirming many of their conclusions by means of investigations on the eggs of different genera and species.

I studied at first only the eggs of *Eustylochus ellipticus* (Girard) Verrill, a polyclad found abundantly in the vicinity of New Haven, Conn., during the winter and spring months, on the beach a little below high water mark, clinging to the under side of large stones. The animals may be kept alive for many weeks in sea-water, if it is occasionally changed. A few eggs were laid in January and February, but more were produced during March, April and May.

Girard (7, 8) published an account of the embryology of this species under the name *Planocera elliptica*, nearly half a century ago. His figures are remarkably well drawn, and considering that he wrote at a time when the maturation, and the significance of the fertilization and cleavage of the egg were not understood, the number of facts correctly observed by him is remarkable. No one else, so far as I am aware, has published anything in regard to its embryology, and of course not only the cytology, but much else remained as a new field for investigation.

The eggs are laid in clusters or sheets containing from one to two dozens up to several hundreds, arranged in a single layer and closely attached together with a white mucus-like secretion, which is at first very sticky and adheres to everything it touches, but gradually becomes harder. The eggs lie so close together in the cluster that the egg membranes, though not the egg itself (for there is a space between them), become more or less polygonal and no definite arrangement of the eggs can usually be made out. In *Planocera nebulosa* Girard, another polyclad of which I afterwards obtained eggs, they are not placed so close together, and their arrangement in a zig-zag line extending back and forth across the cluster, can readily be seen. It took an individual of this latter species less than a minute to lay a row of eggs across a cluster about three-sixteenths of an inch wide and back again, the animal keeping the forward end of the body stationary or advancing it slightly as row after row of eggs was laid, and slowly moving from side to side the posterior part of the body, where the reproductive openings are situated. In the case

of both species the clusters of eggs are usually deposited on the bottom or sides of the jar in which the animals are kept. Sometimes they are laid on the surface of the water and float until once submerged, when they sink to the bottom.

Eggs of *Eustylochus ellipticus.*

The eggs average 0·080^{mm} in diameter. Each is enclosed in a tough membrane more than 0·100^{mm} in diameter, so that the egg is free to move in the clear fluid filling the intervening space. Owing to the large number of yolk globules which it contains I was able to make out nothing definite concerning the internal processes of maturation and cleavage in the entire egg either living or stained.

Development is very slow and varies greatly in the time occupied in the different stages, so that some of the eggs in a cluster are often farther advanced than others. In other cases, however, the eggs of the same cluster are in nearly the same stage.

A few hours after the egg is laid, which occurs more often at night than during the day, it flattens out at one point and the first polar body is given off. The time that elapses before this occurs is probably largely dependent on the temperature, as Francotte found to be the case in the eggs of *Leptoplana.* The polar body exhibits amœboid movements both before and for some time after its complete separation. Fig. 30 shows the different forms assumed by the polar body in one instance, in the course of ten minutes. When the first polar body has separated the egg again becomes spherical but soon flattens again in the same region, and the second polar body separates in a similar manner. Both polar bodies are large, the diameter of the second and smaller one being about one-tenth that of the egg, while the first is about one-half as large again as the second, and usually assumes an elongated form. They usually become detached from the egg after a short time, and float around between it and the egg-membrane, but they show no signs of disintegration even after they have been rolled around in this space for many days by the motion of the cilia which develop on the embryo. I have observed no amœboid movements of the egg itself.

Some twelve or fifteen hours after the egg is laid the first cleavage takes place, though it may occur sooner or be delayed still longer. It is a vertical and so far as I can determine an equal one. The second cleavage planes are not quite vertical but are so inclined that the somewhat smaller cells that are budded off lie in a slightly higher

plane than the others. They separate in the direction of a left-handed spiral. The third cleavage is horizontal and the cells are budded off in the direction of a right-handed spiral. The upper four cells (about the animal pole) are quite conspicuously smaller than the others and of about equal size in spite of the inequality of the cells from which they are derived. The two, four, and eight-cell stages are shown in Figs. 44, 45 and 46.

Eggs of *Planocera nebulosa* Verrill.

In the eggs of *Eustylochus* I was unable to discover the sperm-centrosome and sperm-aster. In the effort to find them many lots of material, in every stage in which these structures might be looked for, were preserved in fixing fluids of different kinds. Dozens of slides were mounted, many of them showing the maturation and cleavage spindles in a beautiful state of preservation and satisfactorily stained. These were gone over with the greatest care with a high power objective, but I failed to find any trace of the sperm-asters or anything that I had any reason to believe was the sperm-centrosome.

Still as the egg of *Eustylochus ellipticus* is densely packed with large yolk globules which not only stain with hæmatoxylin but also with plasma-stains, and are in many preparations so dark colored and densely crowded that the sperm nucleus itself is often impossible to distinguish, I was even then unwilling to accept this negative evidence as final, and determined to examine the eggs of some other planarian, where the conditions might be more favorable.

Through the kindness of Dr. Wesley R. Coe of New Haven, to whom I am also indebted for some preparations of the eggs of *Eustylochus* which he had himself made some time previously, I received during the spring of this year (1899) some living individuals of the rather rare species *Planocera nebulosa* Girard. These he obtained while collecting the large nemertean *Cerebratulus lacteus* Verrill, in the tubes or burrows of which this species usually lives, though it is occasionally found elsewhere. It can be kept in confinement more readily and lays even more freely than *Eustylochus ellipticus*. My specimens laid their eggs in March and April, more abundantly during the latter month.

These specimens of *Planocera nebulosa* were pronounced by Prof. Verrill identical with those he has called by this name in his work on the marine planarians of New England (29). In that work (p.

94) he says of this species: "I have referred this with considerable doubt to Girard's species, for the description of the latter was very meagre. . . . . The generic relations of this species are somewhat doubtful. . . . . In many respects the reproductive organs are like those of *Eustylochus*, and it is possible that the affinities may be even greater with that genus than with *Planocera*."

This question I have not had the material or the opportunity to investigate. The species is, however, a strongly characterized one, both in appearance and habits, and is readily recognizable, so that no confusion will be caused should it prove necessary to transfer it to another genus. It is an exceedingly active creature and crawls with considerable rapidity, for a planarian, while *Eustylochus ellipticus* is very sluggish and moves but little unless disturbed.

The eggs are larger than those of *Eustylochus ellipticus*, measuring 0·090^{mm} or more, but the amount of shrinkage which occurs in preserving the eggs and in imbedding them is so variable that in sections they often appear no larger than those of *Eustylochus*. They are surrounded by a membrane considerably larger than the egg, but in this species it is much thinner, the amount of mucus present about them is less, and they are not laid so close together.

The difference in the size of the eggs of the two species does not seem to affect the size of the mitotic figures, pronuclei or polar bodies, but results simply from an increased amount of cytoplasm and yolk.

The descriptions and figures in the remainder of this paper are taken from eggs of *Eustylochus* unless otherwise stated. Nevertheless the resemblance between the eggs and embryos is so close that they would apply almost equally well to *Planocera nebulosa*. Differences of any importance between the two species have been noted. The methods of preparation used were the same in the case of both species.

Methods of Preparation.

As I have already intimated, it was necessary to depend entirely upon sections for studying the internal processes of development. In preserving the eggs a number of different reagents were tried; saturated solution of corrosive sublimate both with and without the addition of two per cent. of glacial acetic acid or one and one-half per cent. of nitric acid, picro-acetic containing one per cent. of acetic acid, seventy per cent. alcohol with five per cent. of glacial acetic acid, Gilson's, Hermann's, Flemming's and Perenyi's fluids.

With all of these except the last three I obtained at one time or another fair preparations. The chief objection to the fluids containing osmic acid is the difficulty of staining the eggs fixed with them, but in addition to this the structures were usually not so well preserved as with some of the other reagents. On the whole I found the corrosive-acetic and picro-acetic fluids the most satisfactory, and nearly all of my best preparations were preserved in one or the other of these two reagents. The clusters of eggs can be handled entire, but because of the thick membrane and the coating of mucus surrounding the eggs the penetration of the killing fluid is much interfered with, and satisfactory preparations are exceptional, while a large percentage are absolutely worthless.

The appearance of the cytoplasm and yolk in the finished preparation varies with the reagent used in preserving them. Most of the above mentioned fluids, especially those containing corrosive sublimate, harden the yolk globules well, so that they preserve their spherical shape and to a considerable extent their size. They stain quite readily, both with hæmatoxylin and with plasma stains. The picro-acetic fluid, however, allows the yolk spheres to shrink into irregular forms and to so great an extent that the whole egg often becomes greatly contracted and of irregular outline. The yolk has less affinity for stains, and the cytoplasmic reticulum, not the yolk globules as in the corrosive preparations, becomes very conspicuous. I have endeavored to reproduce this appearance in the drawings, some of which (for example, Figs. 2, 11, 25 and 27), were drawn from picro-acetic preparations.

The masses of eggs were usually left in the fixing fluid over night, washed in seventy per cent. alcohol, dehydrated and imbedded in paraffin. I did not meet with any difficulty in imbedding the eggs, nor in cutting them into sections ·007 to ·011^{mm} in thickness, which was as thin as necessary. Many of the preparations could be cut much thinner.

Klinckowström, Francotte and Van der Stricht all found great difficulty in imbedding or cutting their material, but I found no unusual precautions necessary except to take care that the eggs remained in each change of alcohol or clearing fluid long enough to insure thorough penetration. For clearing and as a solvent for the paraffin I used xylol, and my success may have been partly due to the use of this medium as well as to the more favorable material. For the study of the early stages, previous to laying, the entire animals may be killed and imbedded, but as observed by Van der

Stricht, it is better to tear up the animals and to preserve the fragments. In this way more rapid and complete penetration is possible. The fragments of the animal with the eggs still in them were then imbedded and sectioned in the manner described above. For these early stages I found the picro-acetic fluid much the most satisfactory fixing agent.

For staining, Heidenhain's iron-hæmatoxylin method was usually employed, but certain structures, such as the nuclear network of the germinal vesicle, were shown much better by staining with Delafield's hæmatoxylin. With these I generally used a ground stain of Orange G or Bordeaux red, the latter proving the most satisfactory. In using these, particularly the orange, care must be taken not to stain too deeply, as the structure then becomes obscured, and it is difficult or impracticable to extract the stain again. It apparently makes no difference whether the sections are treated with the ground stain before or after the hæmatoxylin.

With saffranin, which was largely used by Van der Stricht, I had little success. When the iron-hæmatoxylin method is used, the yolk globules stain black, but usually a large proportion of them, or sometimes all, become decolorized in the subsequent extraction with the alum solution. If the extraction of the stain is only partial, many of the yolk globules are left with a black center, because of the tendency of the stain to dissolve away first on the outside of the globule, where it is first reached by the solution. Such cases are shown in Figs. 37, 38 and others. Such an object, especially when close to the sperm-nucleus, may easily be mistaken for a centrosome surrounded by a centrosphere. The absence of radiations and the occurrence of such objects in various points of the egg are usually sufficient to show their true nature.

The Germinal Vesicle.

The shape of the eggs contained in the ovaries is determined by the pressure of the adjacent eggs and tissues. With the exception of those of advanced development—those which are forming or have formed the first polar spindle—all contain a large round or oval germinal vesicle (Fig. 1). In sections of fully developed ovarian eggs this may be 0·02^{mm} or more in diameter, and it always contains a large nucleolus, which, as observed by Francotte and Van der Stricht, in the early stages stains more deeply with hæmatoxylin than in the later. It is nearly spherical and bounded by a definite outline. At first it is homogeneous, in later stages sometimes vacuolated, though this may be due to defective preservation.

Owing to the irregular shape of the eggs I cannot say whether the normal position of the germinal vesicle is central or eccentric, nor whether the orientation of the egg is already determined.

The germinal vesicle contains a more or less irregular network of threads which do not stain very dark with Delafield's hæmatoxylin, although with the iron-hæmatoxylin method they stain black. The latter method is, however, poorly adapted for showing the real structure of this network and the early stages of the formation of the chromosomes of the first polar spindle, on account of the tendency to precipitate hæmatoxylin in excess in certain places, increasing largely the apparent amount of chromatic substance and disguising the structure. This has also been noticed by Francotte and Klinckowström. Stained with Delafield's hæmatoxylin the threads are seen to form a network thickened at the nodes and where the strands touch or unite with the nuclear membrane (Fig. 1).

In immature ovarian eggs the cytoplasm is comparatively small in amount and the germinal vesicle occupies a large proportion of the bulk. The change in size and proportions which takes place as the egg ripens is due largely to the formation of the yolk, which, by the time the egg is ready to leave the ovary, is distributed throughout the whole of the cytoplasm in the form of small globules. This comparatively uniform distribution of the yolk persists to a considerable degree through all the maturation and early cleavage stages, so that as a rule only the space occupied by the mitotic figures or nuclei, and sometimes their immediate vicinity, is entirely free from yolk globules.

The cytoplasm appears to consist of a delicate reticulum of threads built up of microsomes staining dark blue with hæmatoxylin, in the meshes of which the yolk globules lie. Besides this there appears to be a clear matrix in which both the reticulum and the yolk globules are contained. Coe (1) observed this in the egg of *Cerebratulus*, but suggests that it may be an appearance due to the shrinkage of the yolk spheres. If no such matrix exists it would seem probable that the cytoplasm has really an alveolar rather than a reticular structure.

The Formation of the First Polar Spindle.

The early stages in the formation of the chromosomes proceed substantially as described by Van der Stricht (28). The observations of Francotte, including those on *Prostheceraeus*, where Klinckowström failed to find a spireme stage, are also much the

same. Near the periphery of the germinal vesicle a part of the nuclear network can be seen to increase in thickness and stain more deeply. It continues to thicken and assumes a beaded outline, showing that it is composed of minute masses or grains of chromatin, connected together (Fig. 2). Whether this is already broken up into segments representing the future chromosomes, when it first becomes noticeably different from the rest of the threads of the network, I have not been able to discover, as it is almost certain to be cut at different points by the planes of the section. In the egg shown in Fig. 2 it is pretty evident that it has already broken up into segments. These show no signs of longitudinal cleavage in anticipation of the division of the chromatin between the egg and the first polar body. They contract into rounded or oval masses (Figs. 3*a* and 3*b*) the chromosomes of the first polar spindle, while the remainder of the nuclear network gradually disappears.

By this time the asters of the future spindle have become distinguishable (Figs. 2, 3*a* and 3*b*). Specimens stained by the iron-hæmatoxylin method show that each contains a black staining centrosome (Figs. 3*a* and 3*b*).

The question of the origin of these centrosomes is one upon which there is great difference of opinion. Klinckowström found the two asters originating separately and simultaneously, their centrosomes lying about ·040^{mm} apart. Van der Stricht's own observations confirm this; nevertheless he expresses his belief in the claim of Francotte that he has found the centrosome single—"nous le voyons s'allonger, puis se fendiller et se diviser ainsi en deux nouveaux corpuscules polaires" (3, p. 12).

In regard to the place and source from which the centrosome or centrosomes take their origin there is also difference of opinion. Klinckowström considered them of nuclear origin, basing this belief, however, on a single instance, of which he gives a figure. Van der Stricht believes that they originate from the nuclear membrane and are therefore of nuclear origin. He finds that they afterwards separate from the membrane. Francotte finds the centrosome appearing close to the nuclear membrane, sometimes "si voisin qu'il semble faire corps avec cette membrane," but does not believe in its nuclear origin.

I have not demonstrated any connection between the centrosomes and the nuclear membrane nor found evidence of their origin by the division of a single body, though this of course may occur before the formation of the aster rays enables us to distinguish them. By

that time they lie in the cytoplasm near the nuclear membrane, which is usually more or less indented, and at a little later stage begins to disappear at these points. They lie widely separated but not necessarily at opposite poles of the germinal vesicle (Figs. 2, 3*a* and 3*b*), and are not connected by a central spindle. The similarity of this mode of appearance to that found by Coe (1) in the nemertean *Cerebratulus* and by Griffin (12) in *Thalassema* is very great. The observations of Coe are of especial importance, for the preparations on which his work is based have surely never been excelled in beauty and clearness of detail, if indeed they have been equalled.

When the centrosomes, which stain black with the iron-hæmatoxylin, first become distinguishable, they are surrounded by a more or less distinct centrosphere, which stains with cytoplasmic stains and runs out into the few short aster rays developed at this early stage. It may be of some significance that there is no distinct line of demarcation between the rays and centrosphere, although in later stages this ceases to be the case. Moreover in this early stage, the rays seem to have but little connection with the cytoplasmic reticulum, but as they become longer they branch and grade imperceptibly into the reticulum with which they are continuous (Figs. 4 and 5), as Wilson (31) has so clearly shown in *Toxopneustes*.

These phenomena suggest that the rays are at first outgrowths of the centrosphere, but grow by the continuous addition and rearrangement of the microsomes of the reticulum. The branching which later becomes noticeable is largely determined by the position of the yolk globules. This would indicate a difference of origin of the basal and peripheral portions of the aster rays. The indications are, however, that the centrosphere itself is differentiated from the cytoplasm surrounding the centrosome by the influence of the latter, making the ultimate origin of both portions of the aster rays the same.

The term *centrosphere*, as I use it, is equivalent to the "centrosom" of Boveri and to the "zone médullaire de la sphère attractive" of Van Beneden and to the "couche médullaire (de la sphère attractive)" of Van der Stricht. Such a structure as the "couche" or "zone corticale de la sphère attractive" of Van Beneden, which is also described by Van der Stricht in *Thysanozoon* and by Francotte, I do not find in well preserved eggs, and I find no evidence of any differentiated body external to and surrounding the centrosphere (Van der Stricht's "couche médullaire"), except the aster rays extending out into the cytoplasm. In poorly preserved eggs I have

sometimes seen more or less suggestion of such a "couche cortical," but cannot consider it as anything but an abnormal or artificial effect, as the best preparations do not show it. An appearance which may be of somewhat the same nature is very frequent in eggs where the penetration of the killing fluid has been slow or imperfect. No centrosome can be found in such eggs and the centrosphere is indefinite in outline and surrounded by a light colored layer of greater or less thickness, in which no structure can be discerned. The aster rays begin outside of this. Such a condition, although unquestionably abnormal and artificial, I have represented in Figs. 24 and 28, as other structures in the egg are well shown in these specimens. It occurs both in the polar and cleavage spindles.

Francotte (4) illustrates in his Figs. 27, 29, 30 and 31, sections which apparently have this same defect, and it is largely upon such that he appears to base his belief that the centrosphere (he calls this with the "corpuscle central" the "centrosome") is surrounded by a membrane in the later phases of mitosis. Such a condition is not indicated by my best preparations, though it is probably true that the outer portion of the centrosphere becomes more dense. At least it stains more deeply. (See Figs. 5, 7, 8, 12 and 13.)

That which I have termed *centrosome* is the "granule central" or "corpuscule central" of Van der Stricht and Francotte, the "centralkorn" of various writers.

Van der Stricht (28) believes that this, as well as the centrosphere ("couche médullaire"), is formed by differentiation out of a "centrosome" which is at first homogeneous. Moreover he considers that although the "sphère attractive," which includes what I have termed the centrosphere, may not always reveal itself with all the clearness that might be desired, yet it is none the less a permanent organ of the cell.

This view is certainly not supported by the subsequent history of the centrosphere in *Eustylochus* or *Planocera*. As explained below, the greater part of it is destined to form the second maturation spindle, and the centrosphere that remains in the egg after the second polar body is expelled rapidly degenerates and disappears. The manner in which the centrosphere is formed is a much more difficult matter to determine, but the poorly defined limits of the centrosphere in the early stages both of the polar and cleavage spindles, where it runs out into the rays with no distinct line of demarcation between the latter and the centrosphere, when compared with its distinct and definitely limited outline in the later stages of the same

spindle, suggest that it is formed by a progressive differentiation of the cytoplasm about the centrosome.

As I have already said, there is at first no central spindle connecting the two asters which are to become the poles of the first polar spindle. They seem to be entirely independent (Figs. 2, 3*a* and 3*b*). But as the nuclear membrane, which has everywhere become very thin and delicate, is more and more completely dissolved, the rays extend into the germinal vesicle and connect with the chromosomes and with rays of the other aster (Fig. 4 and 5). Thus a spindle is formed, the fibers of which are in the early stages very irregular and anastomose with each other in so complex a manner that they appear somewhat like a more condensed and deeply staining part of the general reticulum of the egg.

As Coe (1) has found in the egg of *Cerebratulus*, the spindle is thus partly at least formed from material previously or to some extent still enclosed in the nuclear membrane, and therefore undoubtedly nuclear. This is Francotte's opinion also. Van der Stricht expresses the belief that a rudiment of the central spindle exists from the time the centrosomes first separate, but admits that no such thing is visible in the early stages. It is probable, however, that if such a structure did exist and were sufficiently substantial to persist while the centrosomes move to opposite sides of the germinal vesicle, it would at the same time be distinct enough to be visible.

The development thus far takes place usually in the ovaries or at least in the first portions of the oviducts. Francotte however mentions cases where the egg was laid while still in the germinal vesicle stage. Such instances I have not met with. By the time the egg reaches the uterus (Fig. 5) the first polar spindle is fully formed, the chromosomes lying in or near its equator, though some of them are often more or less displaced (Fig. 36). Their form is now usually that of a ring, a cleft or opening having appeared through the center of each. This ring form is sometimes visible at a still earlier stage (Fig. 3*a*). The other forms which the chromosomes may assume are described below.

About the time the nuclear membrane dissolves the nucleolus disappears also. Occasionally there are traces of it for a little while afterwards both in *Eustylochus* and *Planocera*. Francotte observed this in *Leptoplana* and *Prostheceræus*, but Van der Stricht found that it did not persist after the disappearance of the membrane in *Thysanozoon*.

By this time the aster rays have increased both in length and in

number, and may now be seen to be made up of microsomes, at least so far as their outer portions are concerned. Toward the centers of the asters they appear homogeneous and their structure cannot be made out. They branch and connect with the cytoplasmic reticulum and thus indirectly with the periphery of the egg. The centrosomes (Figs. 5 and 36) have usually divided, so that there are now two in each centrosphere. This division, which may however be delayed till after the egg is laid, usually takes place in the direction of the axis of the spindle or nearly so. This fact I shall have occasion to speak of again, as it affects the process of formation of the second polar spindle. The two derived centrosomes remain quite near together, nevertheless the centrospheres usually become slightly elongated in the direction in which they separate. The centrospheres are now bounded by a definite outline where the aster rays take their origin.

Fertilization.

Eustylochus, like other polyclads, is hermaphroditic, but the eggs of one individual are fertilized by the spermatozoa of another. The spermatozoa may be injected into any part of the body, and find their way to the eggs by their own activity, since they are able to penetrate through the tissues. This process of hypodermic impregnation is described by Lang (18) and other writers in other polyclads. The spermatozoa are introduced into a puncture made in the epidermis of the dorsal surface by the penis of another individual. They are mixed with a quantity of thick mucus so as to form a spermatophore of jelly-like consistency, and of fairly definite form (Fig. 31). This mass of mucus and spermatozoa is not inserted entirely below the epidermis, but the greater portion of it remains projecting out of the animal as a white spherical mass, which may be $0{\cdot}6^{mm}$ or even more in diameter. Sometimes as many as four or five of these spermatophores may be seen projecting from the same individual at various points on the dorsal surface, but more often toward the posterior than the anterior end.

Living spermatozoa are 35–40 μ long, and very slender and thread-like. They taper at each end, but the anterior end is much more slender, exceedingly sharply pointed, and moves in snake-like curves or waves. These waves may travel in either direction, sometimes with considerable rapidity, but with little effect in moving the spermatozoon along in water, though no doubt efficient in penetrating the body-tissues. No definite demarcation between the active

and slender end and the thicker and inactive part, probably the middle piece, is visible, nor can any tail be distinguished.

The spermatozoa are often present in the tissues in almost incredible numbers, and some difficult questions in regard to the details of the process of fertilization present themselves. Although they can penetrate most of the body-tissues without difficulty, there must be others that are more or less impermeable to them, as for example those of the male reproductive organs. Otherwise it would not be possible for an individual to store up the fully developed spermatozoa, or to prevent fertilizing its own eggs.

I have not seen the spermatophores of *Planocera nebulosa* and therefore have not examined and measured the living spermatozoa. I often observed the animals apparently in the act of impregnation, but on examining them found no spermatophore. Judging from preserved specimens of the animals and eggs, the spermatozoa of *Planocera* do not differ from those of *Eustylochus*.

The entrance of the spermatozoon into the egg takes place about the time the process of forming the first polar spindle begins, which as I have said occurs either in the ovary itself or, usually at least, before the egg has got far from it. The possibility suggests itself that the entrance of the spermatozoon may be the stimulus which induces the disappearance of the germinal vesicle and the formation of the spindle.

Another question that arises is why the unripe eggs in the ovaries are not prematurely fertilized. Evidently it is not because the spermatozoa do not have access to the ovaries, although from the numbers of them generally to be seen just outside the ovary, the membrane enclosing the same must serve to keep them out to a considerable extent. The most plausible explanation is that the chemical nature of the egg protoplasm is not such as to attract the spermatozoon until it is of a certain degree of maturity.

It is exceedingly rare to find more than one spermatozoon in an egg. If double fertilization is prevented by the formation of a vitelline membrane as soon as one spermatozoon has entered, the membrane must be extremely delicate, for I have been unable to distinguish such a structure. If present, it doubtless afterwards forms the inner layer of the tough shell which is deposited around each egg by the shell glands just before laying, and later becomes separated from the egg by a considerable space containing a clear fluid, for if this were not the case we should see it when the polar bodies separate. At that time, however, there is no interior mem-

brane visible, but the polar bodies lie free in the space under the shell.

Eggs which lie in the uterus invariably contain a spermatozoon, which lies fully as far removed from the surface as at the end of the second maturation spindle (Figs. 5 and 36). It stains very deeply throughout its whole length and lies curved and twisted into various loops and bends. It is not apparent that it enters at any particular part of the egg's surface or has at this stage any particular position in relation to the spindle, which it often approaches very closely, especially in *Planocera nebulosa*.

At this stage, especially in eggs of *Eustylochus* (it is not usually conspicuous in *Planocera*), the egg-cytoplasm, immediately about one end of the spermatozoon, has a more densely granular appearance and stains more deeply (Figs. 5 and 6). In some preparations this is exceedingly conspicuous (Fig. 6). I have not discovered anything of the nature of a centrosome in this and attribute it to the disintegration of some non-nuclear portion of the spermatozoon. By the time the egg is laid it has disappeared.

In poorly preserved specimens it is not uncommon to find spots and discolorations of various kinds and shapes near the spermatozoon. There is no constancy in their appearance and they do not occur in the best preparations. The egg can remain in the uterus in the conditions shown in Figs. 5 and 36 for an indefinite period. No further change appears to take place until it is laid.

Later Stages of the First Polar Spindle.

A section of a recently laid egg is shown in Fig. 7. The spindle as in other polyclad eggs has a central position, and measures between the centers of the asters three-eighths or more of the diameter of the egg. The two centrosomes in each aster often lie so near together that unless the extraction of the stain is carried sufficiently far they cannot be distinguished as separate, though usually the centrosome, if but one appears, has an elongated form showing that it may be double. The centrosphere surrounding them appears homogeneous in structure, and is elongated in the direction of the axis of the spindle. It has gradually become bounded by a distinct and smooth outline, from which the rays, still rather few in number and about one-half the length of the spindle, have their origin. They branch and are lost in the spaces between the yolk globules, which are quite uniformly distributed in the egg, and come close to the spindle and centrospheres.

The spindle fibers, as in the earlier stages, are few in number and slender, but have become much more regular. The chromosomes generally have still the ring structure though they are now elongated and oval in outline.

At this time the asters of the spindle are alike in size and appearance and it cannot be predicted which one is to pass into the polar body. But soon one pole of the spindle approaches the surface of the egg.

This is accomplished by a movement of the whole spindle, which meanwhile shortens to about one-third of the diameter of the egg or even less. The aster of the outer pole becomes reduced in size, and some of the rays necessarily disappear altogether as the centrosphere approaches and finally comes in contact with the surface of the egg (Fig. 8). Finally the last of the rays at this pole and the centrosphere itself fade away.

Division of the Chromatin.

The shape of the chromosomes in the equatorial plate is very variable, and at first sight it would appear difficult to derive some of the forms from the closed rings. Very similar if not absolutely identical forms are found in all the species of polyclads described by the writers already referred to. Van der Stricht has given the most thorough discussion of the relation of the different forms of chromosomes to the original elongated segment and to the ring derived from it. His conclusions are for the most part confirmed or at least supported by what I have observed in *Eustylochus* and *Planocera*.

There is, I think, little room for question that we have here a true case of heterotypical mitosis (Flemming, 2). No longitudinal splitting can be seen in the elongated beaded segment which is the first stage of the chromosome. The first sign of its approaching division, the cleft or opening through it, does not appear until it has contracted into so nearly round or oval a form that from its shape we cannot do much more than guess which diameter represents the original long axis of the chromosome. If we are to ascertain whether this cleft really is a longitudinal cleavage, an "aequationsteilung" of the chromatin, we must find some other means to determine it.

The way that the ring opens and divides proves that it consists of two elongated segments, each bent into a semi-circle or U and joined end to end. The junctions of these segments therefore come at opposite points on the ring. The spindle fibers attach themselves

to points midway between these junctions, and as they draw upon them the ring becomes a more and more elongated ellipse. As the points where the spindle fibers are attached move apart the line joining them becomes the long axis of the ellipse, and the points of union of the segments the extremities of the short axis. The ring then breaks at one of these points, and the tension of the spindle fibers then tends to straighten the whole chromosome (which now consists of two long segments joined at one end only) and to bring it into a line parallel to the spindle fibers. The junction of the segments then comes at the middle point of the long slender rod thus produced, which is not necessarily a straight one. Eventually it breaks here also and the derived chromosomes, each having the form of a shorter rod, usually bent into a U form, pass to their respective poles of the spindle. As the spindle fibers are not attached to the ends of the segments but near their middle, the long rod before division is usually more or less curved or hooked at each end, the extreme ends not being so rapidly drawn toward the spindle poles as the points half way toward the middle where the spindle fibers are inserted. The segments derived from either this or the straighter form regularly have a U form on account of the tension being applied to the middle of their length instead of the end or ends. Another effect of the tensions thus applied, is to twist the chromosome as soon as the ring has broken at one point. This, together with the hooked end and a tendency which the segments have to become knobbed at their ends (including those that remain joined) often causes the chromosome as a whole to assume an appearance strikingly like an italic letter *f*. The successive stages I have shown diagrammatically in Fig. 41. Actual examples appear in Figs. 9, 10 and 36.

This process of division may be regarded as the regular one, and the other methods which occur as modifications of it. The most important modification is produced apparently by an increased amount of cohesion of the ends of the future segments when the chromosome still forms a closed ring. As before, it is drawn out into an ellipse with the junctions of the end of the segments at the ends of the short axis. Instead, however, of the ring opening at one of these points the segments continue to hold together, the ellipse becomes more and more elongated, and the sides eventually come together and apparently fuse, making instead of a long narrow rod consisting of the future segments united to each other by one end of each, a short thick rod in which each segment has the form of a loop the two

arms of which have come together and fused. As in the form first described, a transverse division of the rod at its middle point finally separates the derived segments. In the latter form, however, they are joined by both ends, in the former by but one end of each. This process is shown diagrammatically in Fig. 42. Actual examples in different stages appear in Figs. 9, 10 and 11.

Both these processes were recognized by Francotte but described with especial care and fullness by Van der Stricht (28). Klinckowström figured them but gave little explanation. We often—indeed I might say generally—find different stages of both of these processes going on in different chromosomes of the same spindle. Of each there are many minor modifications, so that a great variety of forms results. Most of them are due to the tendency of the derived segments to thicken at certain points, especially at the middle (where, as I shall describe later, they are probably destined to divide in the second polar spindle) and at the ends, where they form knobs. These thickenings often become conspicuous long before there is any sign of separation at these points, or even in the ring stage. The result, when it occurs early, is that the ring is thickened at four points, giving the appearance of a tetrad group connected by narrower commissures. Such figures are mentioned by Francotte. It is however in these thickened places, and not between them, that the chromosome finally divides.

By far the most interesting modification is one which gives us some suggestion in regard to the distribution of the chromatin. The actual partition of the chromosome in both the methods above described is transverse to its long axis. The important question is whether this partition is transverse to the original long axis of the beaded segments found in the early stages of spindle formation, in other words, whether we have an equal or a reducing division of the chromatin. The modification which gives us a hint in regard to this important matter is shown in Fig. 43, examples of it also in Fig. 10.

This diagram (Fig. 43) shows not successive stages in the history of a chromosome as the other two diagrams, but different degrees of modification from the type shown in Fig. 42. As will be understood from the figures, in its extreme form it results in a cross-shaped chromosome. Such forms are described but not explained by Van der Stricht. The interesting point about this form is that it would hardly be possible to produce it unless the cleavage of the chromosome which produces the ring is actually a longitudinal one. Here

we see that the segments are not attached by their ends only, but also for a considerable distance (varying in different cases) along towards their middle points, showing what their original relations to each other are.

This supports Van der Stricht's opinion that the first division is in reality a longitudinal or equal one, and his suggestion that the same explanations would clear up the apparently transverse division described by Korschelt (15, 16) in *Ophryotrocha*.

Van der Stricht describes "secondary rings" formed by the refusion of the ends of segments already separated. It is not necessary to assume such an unlikely process for the explanation of any of the forms. Where we find the ends of the segments united, it is much more reasonable to suppose that they have not yet separated. I cannot believe that the open loops figured by Van der Stricht are destined to form rings again. The only case when there is indication of fusion is in the form of chromosome shown in Fig. 42, where the sides of the ellipse apparently do actually fuse, converting the ellipse into a solid rod.

The derived segments of chromatin which result from the form of division shown in Fig. 42 are short thick rods and are really the same as the loops resulting from the form shown in Fig. 41 except that the two sides of the loop have come together and fused.

The Centrosomes and Asters.

While the aster rays of the other pole of the spindle have, as already mentioned, become reduced, those of the inner pole have become longer, stouter and more numerous. The centrosphere of this pole has become proportionately larger, and its two centrosomes have moved a little farther apart. The centrosomes seem to vary greatly in size. MacFarland (20) in describing the first polar spindle of *Diaulula*, says that the size of the central granule ("centralkorn"), which undoubtedly corresponds to what I have in this description called the centrosome, is dependent, within certain limits, upon the extent to which the stain is extracted. Kostanecki and Siedlecki (17) found much the same thing in the case of the cleavage centrosomes of *Ascaris*, where Fürst (5) was even led to believe that they are nothing more than artefacts. Though I think that it would be impossible to explain the distinctness, the definite form, and especially the division of the black staining center of the asters in such eggs as *Diaulula* and *Eustylochus*, on the supposition that the centrosome is

only the portion left colored after a partial extraction of the stain, the iron-hæmatoxylin method may evidently mislead us as to the actual size of this organ. In the present case the deeply stained center of the aster may be reduced by continued extraction with the alum solution from a body apparently occupying the whole centrosphere, down to one so minute as to be scarcely visible with the highest powers of the microscope, or it may be entirely dissolved away.

The enormous centrosomes, often unsurrounded by any indication of a centrosphere, which appear in some of the illustrations of Klinckowström and Francotte, are probably due to the whole centrosphere being stained.

Figs. 12 and 13 are later stages of the spindle, showing the separation of the derived chromosomes and the formation of the polar body. The divergence of the centrosomes of the inner pole in preparation for the second polar spindle may already be noticed. The rapidity with which they move apart, or the time when they start to do so, is not dependent upon the rate of separation of the chromosomes. This will readily be seen by comparing the progress made in these processes in the eggs shown in Figs. 12 and 13. Often as the centrosomes separate a constriction appears in the outline of the centrosphere between the centrosomes (Fig. 12). This appears to happen only when the latter move apart at an early stage. If their separation does not proceed far before the first polar body is separated the constriction does not appear. The centrosphere simply elongates and the new spindle forms as described below.

The segments resulting from the division of each chromosome remain connected by distinct and rather thick fibers even after they have become widely separated (Figs. 12 and 13). In the late phases they are generally closely grouped together. In the final stage of the spindle no true cell-plate is found, although such a structure is often quite noticeable in the second polar spindle. This was also noted by Wheeler (30) in *Mysostoma* and by Coe (1) in *Cerebratulus*.

The Number of Chromosomes.

In *Eustylochus ellipticus* the number of chromosomes in the polar spindles is ten, and therefore twenty in the cleavage spindles, though they are then much more difficult to count. I have determined the number to be the same in *Planocera nebulosa* with almost as great a degree of certainty.

Van der Stricht found nine in the polar spindle of *Thysanozoon Brocchi*, Klinckowström and Francotte six in the polar spindle of *Prosthecereus vittatus* and Francotte eight in the polar spindles of *Leptoplana tremellaris*, *Oligocladus auritus*, *Cycloporus papillosus* and *Prosthiostomum siphunculus*.

The Second Polar Spindle.

The centrosomes at the inner pole of the spindle continue to move apart and the centrosphere to become more elongated. Meanwhile the spindle fibers remaining in the egg degenerate and disappear, and the aster fibers also undergo degeneration, becoming fewer in number as well as shorter and less conspicuous. The extent to which this occurs appears to vary greatly in individual eggs but is never, as far as I have seen, carried to complete disappearance. The centrosphere of the inner pole of the first spindle soon begins to assume the form of a spindle (Fig. 14), even while the centrosomes are still quite near together. A light area appears between the centrosomes in the elongating centrosphere. This approaches almost to each centrosome and is, as MacFarland (20) found in *Diaulula*, without definite outline toward the ends of the incipient spindle. The constriction of the centrosphere mentioned in describing the first polar spindle, has disappeared.

At a little later stage (Fig. 15) the centrosomes have moved farther apart and in the light central area a few fibers may be distinguished which increase in number and length as the spindle lengthens. The aster rays also increase in number and length as the spindle grows, though they never attain the development found in the first polar spindle. The portion of the old centrosphere surrounding each centrosome assumes the outline and appearance of a complete centrosphere, while some of the aster rays, attaching themselves to the chromosomes draw them into the equator and become the mantle fibers. Thus with the exception of the chromosomes, and the outer portions of the aster rays as far as they are built up from the granules of the cytoplasm, the entire mitotic figure appears to be derived from the centrosphere of the inner pole of the preceding spindle.

This seems enough to prove the incorrectness of calling the centrosphere the "centrosom," as MacFarland (20) has done in describing the maturation of the mollusk *Diaulula*. It is evident that we are not dealing with the centrosome only, but with much else in addition, and that such a use of the term is not in harmony with its definition as a permanent and self-perpetuating organ of the cell. If we are

to apply the term to any visible object it must be the black staining "centralkorn."

I have already stated that when the centrosome in each aster of the first polar spindle divides, the derived centrosomes usually separate in the direction of the axis of the spindle or nearly so (Figs. 5, 7, 8, 12 and 13). This applies especially to *Eustylochus;* in *Planocera* we find variations more frequent, and it is not rare to find them moving apart in a direction very oblique or even transverse to the spindle axis (Fig. 37), which is rather uncommon in *Eustylochus*, though not sufficiently so to be abnormal. The result of this is that the second polar spindle when formed has already a radial or nearly radial position, and no rotation of the spindle, or at least only a slight one, is necessary. The outer pole simply moves toward the surface of the egg, the spindle meanwhile lengthening, while the inner pole does not change its position to any great extent. According to Lillie (19), a similar position of the spindle is common in *Unio*. As the outer pole moves toward the periphery of the egg it often pushes directly through the group of chromosomes, and thus some of the aster rays attach themselves to these and draw them into the equatorial part of the spindle.

Van der Stricht, on the contrary, finds the centrosomes in *Thysanozoon* lying usually in a line perpendicular to the spindle axis, though occasionally parallel or identical with it or in intermediate positions. Klinckowström in *Prostheceraeus* also finds the second polar spindle in a tangential position during its early stages.

The question of the relation of the aster rays of the second polar spindle to those of the inner pole of the first, is a most difficult one to answer. This is largely because of the very different appearances which eggs in about the same stage present.

MacFarland (20) describes the rays of the second polar spindle as arising anew, but before the outer portions of the rays of the old aster have entirely disappeared, so that we have at one time two sets of radiations present, the short new rays, and outside these, surrounding the whole spindle, the old aster rays whose central portions have disappeared.

Some of my preparations suggest such a process. Fig. 37, representing an egg of *Planocera nebulosa*, shows one of these. The rays of the first polar spindle aster become weak as they approach the centrosphere, which looks as if it were developing new rays. Yet a careful examination of this specimen shows that the old rays may be traced clear to the centrosphere. Such a specimen as that shown in

Fig. 14 also suggests that new rays are being formed, the old ones having already disappeared.

Yet, on the other hand, there are many cases where we can scarcely doubt that the centrosphere simply lengthens and divides, each part carrying its rays with it, although the latter may become reduced in strength. In support of this, it is worth mentioning that although I have a very large amount of good material in this stage, particularly of *Planocera nebulosa*, I have never found a case where the rays had disappeared entirely nor one where I could distinguish an old and a new set of rays with certainty.

I think therefore that the conclusion is inevitable that the aster rays of the inner pole of the first polar spindle persist in part as rays of the second polar spindle asters, and my preparations further indicate that the extent to which they do this, and the extent to which new radiations are developed, varies greatly in individual eggs.

I do not find the rays at any period penetrating the centrosphere and reaching the centrosome as described by Van der Stricht, Francotte and many who have studied the eggs of animals of other classes, though during the process of forming the spindle the centrospheres have a more or less indefinite outline. As the centrosphere of the first polar spindle elongates, the part of it immediately surrounding the derived centrosomes becomes the centrosphere of the second polar spindle aster.

The second polar spindle (Fig. 16) is shorter and wider than the first, the aster rays are fewer and shorter and the chromosomes more or less widely separated in a lateral direction, which is in strong contrast to their crowded position in the late stages of the first polar spindle (Fig. 13).

The chromosomes of the second polar spindle are many times smaller than in the first and are less easily stained. Their form is usually irregular and they often divide while the spindle is in an early stage (Figs. 14 and 15).

The cross form described by Klinckowström, Francotte and Van der Stricht is also found occasionally in my preparations. It is explained by the latter as two short rods, the segments derived from the division of the chromosome lying across each other at right angles.

Although some specimens appear to support the theory that the division of the chromatin is here a transverse and reducing division, I cannot claim to have determined the relation of this plane of division of the chromatin to the previous one, as Van der Stricht

appears to have done with some degree of certainty. Neither Klinckowström or Francotte give any evidence in support of this conclusion, upon which, nevertheless, they base their schemes of the distribution of the chromatin in the egg and the polar bodies.

Fig. 17 shows a very late stage of the second polar spindle, though most of the second polar body, which is here already constricted off, lies in another section. The chromosomes have swelled up into vesicles, in which a few threads of a network are beginning to appear, but as yet no nucleoli. The aster rays, centrosphere and centrosome (it does not divide) have not yet begun to degenerate. This is the last stage in which I have found this centrosome.

The Female Pronucleus.

The vesicles formed from the chromosomes remaining in the egg after the second polar body has been expelled, increase in size and fuse together to form a single large one, the female pronucleus, which is at first irregularly lobed and elongated in a direction transverse to the main axis of the egg. This fusion may occur while the vesicles are still small, or it may be delayed till shortly before the formation of the cleavage spindle. The following figures illustrate the process: Figs. 17, 19, 20 and 21.

The longer diameter of the pronucleus may exceed one-quarter of that of the egg. In the vesicles which form it, and in the pronucleus itself, there is a rather coarse network, which, however, does not stain deeply during these stages. At the junctions of the fibers of the network, and where they touch the nuclear membrane, are thickenings due apparently to accumulations of the substance composing the fibers. In addition to the network, there are in the fully formed pronucleus several nucleoli of unequal size. One of these usually originates in each vesicle, and as the latter become fused the nucleoli also increase in size and unite, so that in the completed pronucleus instead of ten nucleoli there are perhaps three or four quite large ones. Their staining power, which is at first considerable, meanwhile decreases so that they stain only with plasma stains. They are spherical and bounded by a distinct outline. From the way they fuse together they are probably of a viscous or semi-fluid nature in the living egg.

A short time before the membrane of the pronucleus begins to disappear for the formation of the cleavage spindle the nucleoli vanish. They are sometimes vacuolated before the time of dis-

appearing; in other preparations they become very pale and appear to dissolve away in the contents of the pronucleus.

These nucleoli seem to be waste matter, and resemble in every particular the nucleoli of the male pronucleus, and those of the nuclei of the cleavage stages.

While these changes have been going on, the female pronucleus has moved a little toward the center of the egg, keeping, however, on or near the line from the center to the animal pole. The aster of the second polar spindle, which remains in the egg, meanwhile degenerates, the centrosome and centrosphere disappear, and all that remains is a spherical mass of bluish stainy granules, apparently the microsomes of which the aster rays were made up (Figs. 19*a*, 20 and 21). This also moves to a more central position in the egg. In the eggs of *Planocera* it is much less conspicuous than in those of *Eustylochus*, where, however, it is much more noticeable in some preparations then in others. No yolk globules are found within the area occupied by this granular mass.

The Male Pronucleus.

I have given an account of the spermatozoon up to the time when the egg reaches the uterus. No change appears to take place in it until after the egg is laid. In a recently laid egg (Fig. 7) the dark colored area in the egg cytoplasm by which one end (probably the posterior, or middle piece) of the spermatozoon was surrounded, has disappeared and the spermatozoon has contracted into a shorter and thicker form, so that it is now spindle shaped. During the succeeding stages of the first polar spindle it contracts still more, becoming irregularly rounded or oval. It also loses its homogeneous appearance and becomes transformed into a vesicle in which a reticulum, and later one or more nucleoli similar to those in the female pronucleus, make their appearance (Figs. 18, 39 and 40).

It is generally still quite small at the end of the maturation period. In its final stages it appears to have precisely the same structure as the female pronucleus, but may generally be distinguished by one or more of the following characteristics: its greater distance from the animal pole, more regular form, slightly smaller size, and smaller number of nucleoli. As a comparison of the above figures will readily show, its development does not necessarily keep pace with that of the female elements, but each develops independently of the other.

As has already been described, the spermatozoon quickly penetrates to a considerable distance from the surface of the egg and apparently remains practically stationary until maturation is complete. When the first polar spindle has taken its final position and we can recognize the animal pole of the egg, we find that it more often lies in the hemisphere away from the animal pole and has evidently entered at some point on the surface of that hemisphere. This statement however applies to *Eustylochus* only; in *Planocera* it is perhaps more frequent to find the sperm-nucleus in the upper hemisphere. In this species it usually lies closer to the center of the egg and consequently often very near the polar spindle aster (Figs. 38 and 40). This more central position is often noticeable even in uterine eggs (Fig. 36).

The movements which bring the pronuclei together seem to be chiefly movements directed toward the center of the egg, both on the part of the male and the female. Just before the formation of the cleavage spindle we find them usually quite near together in the central part of the egg, the female nearer the animal pole.

The Polar Bodies.

During the pronuclear stages the polar bodies usually lie side by side, touching each other and the egg, showing that the point of separation of the second is nearly but probably not quite coincident with that of the first. There is generally considerable difference in the arrangement of the chromatin in the two polar bodies. In the first it remains in a compact group, which often appears to be composed of beaded threads. In the second, however, the rounded chromosomes are scattered irregularly in the cytoplasm of the polar body and are often widely separated. This difference is suggestive of, and doubtless largely due to, the form and arrangement of the chromosomes in the later stages of the first and second polar spindles respectively. The first polar body rarely if ever divides.

The Sperm-centrosomes and their Asters.

These are shown in a number of my specimens of *Planocera nebulosa*, though the examples illustrated (Figs. 38, 39 and 40) are cases where they are visible with unusual clearness. I attribute my failure to find them in *Eustylochus* to the same causes which make them indistinguishable in many preparations of *Planocera nebulosa*. The radiations are very few and short as well as very weak and

developed during a brief stage only, and they are doubtless often obscured by the densely crowded and dark colored yolk spheres. The centrosomes and centrospheres moreover greatly resemble in size and staining qualities the yolk spheres with black centers which I have already alluded to.

In *Planocera* I have distinguished the sperm-centrosome with certainty only in eggs in the late stages of the first polar spindle and in the second polar spindle stages. Earlier than this it is probably also visible, but until definite radiations develop I cannot certainly identify it. When the centrosome can be recognized it is still single (Fig. 38). It is surrounded by a distinct centrosphere and by short radiations which can be seen to be made up of microsomes even close up to the centrosphere. Subsequently the centrosome divides into two (Fig. 39) which separate, the centrosphere meanwhile elongating (Fig. 40) and eventually dividing, forming two asters. From the position of the aster or asters, which is in nearly every case somewhere on the line which the spermatozoon has probably travelled in penetrating to the position where we find it, they have separated from the spermatozoon at a considerably earlier stage. If this surmise is correct it may explain one specimen which for a time seemed very puzzling, in which the polar spindle lies between the spermatozoon and the sperm-aster. But if the sperm-centrosome separates from the nucleus before the polar spindle reaches its peripheral position, it is not unlikely that this would occasionally happen to move between the sperm-nucleus and its aster.

Van der Stricht found sperm-centrosomes and asters only in the eggs where the sperm-nucleus lay near the vegetative pole or near the center of the egg. I do not find that the position of the spermatozoon has anything to do with their presence or apparent absence. I have not succeeded in learning anything of the subsequent history of these asters or centrosomes, nor demonstrated any connection between them and the cleavage centrosomes.

The First Cleavage Spindle.

For a long time after the second polar body has separated the granular remains of the inner aster of the polar spindle continue to be visible. It has already been described as an area free from yolk where the cytoplasmic microsomes, which stain blue with hæmatoxylin, are particularly abundant and conspicuous (Figs. 19*a* and

20). These have for a time a suggestion of their former arrangement in radial lines (Fig. 19*a*).

This may have practically disappeared by the time the pronuclei have their final position, but there remains at least an area free from yolk the position of which (central to the female pronucleus) is between the pronuclei when they approach each other, and in it the cleavage spindle appears.

Some of my specimens (Figs. 22 and 24 for example) plainly show that the spindle is at first short but afterwards increases in length. This indicates that the asters arise by the division of a single one. If we are ready to believe that the cleavage-centrosomes are derived from the spermatozoon, this would support Van der Stricht's theory that the separation of the sperm-centrosome from the sperm-nucleus, and consequently its division into two, is often delayed until this stage.

On the other hand, my preparations of *Planocera* indicate that the sperm-centrosome separates from the nucleus very early and that it divides during the maturation stages. I have not observed a case where the cleavage aster is still single. Fig. 22 shows the nearest approach to this condition that I have found. It also shows the first appearance of the cleavage centrosomes.

From their first appearance (Fig. 22) the asters are connected by a central spindle and the centrosomes are surrounded by centrospheres which become more definite in outline in the later stages. Beaded threads of chromatin, staining more deeply than the remainder of the network, appear within the pronuclei. The aster rays begin to penetrate the pronuclei, whose membranes begin to dissolve away in the vicinity of the centrosomes. The threads of chromatin break up into segments, the chromosomes of the cleavage spindle, which continue to shorten and thicken and finally assume the form of a rather short rod with smooth outline bent into the shape of a U or a V with the point rounded. Ten are formed from each pronucleus.

The spindle continues to grow, its aster rays and fibres increasing in number. If it did not at first lie transverse to the main axis of the egg, it rotates sufficiently to take such a direction. It usually lies almost in the center of the egg. The aster-fibres attach themselves to the chromosomes and draw them into the equator of the spindle, where they take a position with the free ends of the loops directed away from the axis of the spindle. They lie near the outer part or circumference of the equatorial plane of the spindle.

Through the center of this circle or ring of chromosomes a large number of central fibres pass directly from one aster to the other. Figs. 23, 24 and 25 show the successive stages in this process.

I have already described the way in which the nucleoli disappear. The portion of the reticulum of the pronuclei which is not to develop into the chromosomes disappears about the same time as the nuclear membranes.

In *Eustylochus* and *Planocera* the pronuclei ordinarily do not fuse, and their membranes may disappear while they are still quite far apart, so that the spindle contains for a time two well separated groups of chromosomes, derived from the egg and spermatozoon respectively (Fig. 24). At a later stage we can no longer distinguish these groups. I have also found a few instances like the one mentioned by Francotte, where the chromosomes of one pronucleus developed and the membrane disappeared while the other pronucleus was still intact.

The minute structure of the centrospheres, aster rays and spindle fibres does not appear to differ from that already described in the polar spindles. In length the cleavage spindle does not exceed that which is often attained by the first polar spindle, but it is much thicker and the asters are generally larger.

When the chromosomes finally divide each splits lengthwise, forming two U-shaped pieces which are drawn toward the opposite poles of the spindle (Fig. 26). An indistinct cell-plate, consisting of a thickening of the central fibres at their middle point, is then generally noticeable.

Meanwhile the centrosomes in each pole of the spindle have divided, the derived centrosomes usually separating in a direction transverse to the axis of the spindle (Fig. 26). They lie near the middle of the centrosphere, not toward the outside or part most removed from the equator of the spindle, and therefore much nearer to the chromosomes than occurs in *Thalassema* as described by Griffin (12). I have not observed the small asters within the centrosphere described by this author and by Coe (1). When the egg has divided, the chromosomes swell up into vesicles in which nucleoli and a reticulum appear, and the vesicles in each blastomere fuse into a resting nucleus, but the process so closely resembles the formation of the female pronucleus that its description and illustration would be superfluous.

The Second and Later Cleavages.

The conditions in the case of these planarians are particularly unfavorable for tracing the cleavage centrosomes through from one division to the next, for a stage intervenes when the aster rays of the preceding spindle have disappeared or practically so, and the new rays have not as yet developed. All that remains is an area of granular protoplasm lying against the nucleus, very similar in appearance to that found in the earlier stages already described, and there are generally black staining spots or granules present, making it impossible to recognize the centrosomes. By the time the new aster rays are visible these lie, if not on opposite sides of the nucleus, at least widely apart, and no central spindle can be seen connecting them. At an earlier stage such a spindle may exist, but the specimens upon which this opinion is based are too obscure to be of much value in proving it.

The chromosomes of the second cleavage spindle are formed in the same way as those of the first, except that they are all derived from the single nucleus instead of from the two pronuclei. A part of the nuclear reticulum begins to stain deeply, the nucleoli disappear and the membrane is dissolved as in the case of the pronuclei. In the subsequent phases the second cleavage spindle resembles the first.

As already mentioned, the second cleavage is somewhat unequal, and the third is still more so. Mitosis in the later stages seems to follow the same rules, but as the cells become smaller its observation presents more difficulties. In the late stages the centrosomes and centrospheres are larger and the spindle proportionately shorter and wider. This is already quite apparent in the third cleavage spindle shown in Fig. 29.

Later Development of the Embryo.

The development goes on both by the division of the small cells and by the budding off of more small cells from the large ones, but I have not attempted to work out the cell-lineage. *Eustylochus* is a most unfavorable animal for this kind of work because of the small differences in the size of the blastomeres, in which it is unlike some other polyclads, especially *Discocelis*, described by Lang (18). The slowness of development and the opaqueness of the blastomeres add to the difficulty.

The result of the succeeding divisions is that a cap or envelope of small ectoderm cells extends further and further from the animal

pole, and finally encloses the whole egg, the large cells of the lower hemisphere becoming enclosed within the ectoderm layer. In this manner a spherical embryo is formed which is really a modified gastrula.

The time occupied in developing up to this stage is variable. Eggs may occupy eight hours or more between the two and the thirty-two cell stage. In the course of a few hours more the cells become so numerous that it is difficult to count them. During the two or three days following the time when the ectoderm overgrows the egg the interior cells undergo a change, their outlines become less distinct than those of the ectoderm cells, and nothing but the nuclei and yolk spheres can be distinguished in the living specimen. The consistency of the interior cells becomes less firm and they seem to be more or less free to move about.

As the development proceeds a number of large oval bodies of different sizes become conspicuous within the embryo. These are shown in the figures of the later stages (Figs. 32, 33 and 34). They were noticed by Girard, who considered them to be cavities. They are, however, solid bodies,—large cells from the lower hemisphere of the egg densely packed with yolk, which seems in some of them to fuse to a single large mass occupying most of the cell, like the fat in adipose tissue.

When four or five days old the embryo, still practically spherical, develops cilia, and begins to revolve within the egg-membrane. About the same time active contractile movements commence. As development proceeds it becomes somewhat elongated, and therefore is necessarily more or less bent or folded within the membrane. By this time the anterior and posterior ends may be readily distinguished, whereas in the earlier stages this is a matter of great difficulty on account of the small difference in the size of the blastomeres. There is, however, no reason to doubt that this is already determined at a very early stage, as it is in polyclads like *Discocelis*, where the conditions for demonstrating it are not so unfavorable. As the embryo lies in the egg the dorsal surface is the more convex; the ventral surface shows a transverse fold due to the bending of the embryo already mentioned. On the posterior ventral surface two longitudinal lobes appear, separated by a median groove or depression (Fig. 32).

About six days after the egg is laid a very dark brown pigment spot, or eye, becomes visible near the anterior end on the left side. It is at first small and irregular in shape, though it afterwards in-

creases in size and becomes circular. It lies in or attached to the ectoderm but does not reach the surface. A day or so later another spot appears in a similar position on the right side. This also increases in size, but for many days that on the left side is conspicuously larger (Fig. 32). Occasionally an embryo presents an abnormality in regard to the number and arrangement of the pigment spots, but so far as I have discovered, the earlier appearance and larger size of that on the left side is invariable. Except for this the embryo is bilaterally symmetrical, if we leave out of account the large yolk-masses which change their position as the animal turns and contracts.

Later the surface of each eye-spot becomes concave, and in the concavity a transparent vesicle is developed.

By the time the eyes have appeared, the ectoderm in the depression between the ventral lobes, mentioned above, can be seen to be deeply bent inward into a funnel-shaped cavity extending upward and somewhat forward. At the anterior end of the embryo, almost between the eyes, a few stiff hairs grow out in a group and generally adhere so closely together that the group appears like a single coarse flagellum. Later a similar, but at first shorter, group appears at the posterior end. All these structures are developed by the time the embryo escapes from the egg-membrane. They can, however, be much more easily observed after this has occurred, which may be anywhere from ten days to two weeks after the egg is laid, or occasionally longer. Toward the last the egg-membrane becomes very thin, and with the most careful handling many embryos will be prematurely released. For several days before the embryo escapes its movements are very active, and if the membrane is torn it swims rapidly away by means of the cilia. Contrary to what Girard says, I find that the embryo almost always swims with the anterior end directed forwards, but it keeps turning about its longer axis so that the ventral surface is often upward.

Fig. 32 shows an embryo which was drawn as it was endeavoring to escape through a small hole torn in the egg-membrane, and Fig. 33 one in about the same stage removed from the membrane and seen from one side. These were about eight days old. But little further change takes place up to the time of hatching. In the course of the first few days after hatching the embryos assume the curious form shown in Fig. 34, though there does not seem to be any considerable change in the internal structure during the interval. Fig. 35 shows a still later stage; the external form is similar to that

in Fig. 34; the posterior part of the body is, however, much more prominently developed than in the earlier stage, and now forms a distinct posterior median lobe. The large yolk-cells have by this time become divided up, and most of the yolk has evidently been absorbed, but some dark colored substance is left which may be a remnant of it.

The invagination between the posterior ventral lobes has also become wider and more conspicuous, but I have not been able to find at this stage any internal cavity with which it might communicate. I have never seen one of the embryos eat anything, neither will they ingest powdered carmine.

Their bulk has not changed appreciably from that of the egg, and so far they have been living on the yolk stored up within the cells. When this is gone (as in the stage shown in Fig. 35) the embryo soon dies. I have never been able to raise them any farther. If they live longer they do not develop, but degenerate and lose their activity. I found no indications of the peculiar chrysalis stage which Girard described, and am convinced that he mistook some other organism present with the embryos for a stage of the latter. As might be expected, the development of *Eustylochus* resembles closely that of the related polyclad *Stylochus pilidium*, described by Goette (9, 10, 11) and Lang (18).

The later development of *Planocera nebulosa* does not differ much from that of *Eustylochus ellipticus*. In the early cleavage stages there is a little more difference in the size of the blastomeres. The embryos are of course a little larger and the development is somewhat slower. I have kept them for nine or ten days before the eyes began to appear. The left eye develops first, as in *Eustylochus*.

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EXPLANATION OF PLATES.

With the exception of Figs. 30, 31, 41, 42 and 43, all the figures were drawn with the aid of a camera lucida.

In illustrating the development of the egg, I have avoided making up figures by combining into one drawing structures which appear in different sections in the preparation, preferring to reproduce more than one section where this is necessary.

The preparations from which the figures of sections were drawn were made with corrosive-acetic solution and stained by Heidenhain's iron-hæmatoxylin method.

To this Figs. 1 to 5 inclusive, also 11, 25, 26, 27 and 36 are exceptions. These were preserved with picro-acetic solution, which, as mentioned in the descriptive part, renders the yolk globules inconspicuous, but brings out the reticulum of the cytoplasm strongly.

Any other exceptions are mentioned in describing the individual figures.

All represent the eggs or embryos of *Eustylochus ellipticus* (Girard) Verrill, unless otherwise mentioned.

Plate XXXVI.

Fig. 1.—Young ovarian egg, showing the large germinal vesicle, the nuclear reticulum and large nucleolus. Enlarged 860 diameters.

Fig. 2.—Ripe egg in which the first polar spindle asters are visible, though they do not show the centrosomes. Preparation stained with Delafield's hæmatoxylin. Most of one aster lies in another section. The nucleolus has disappeared, and the beaded threads of chromatin have become conspicuous. × 860.

Figs. 3*a* and 3*b*.—Sections of the same egg, which is in a later stage than fig. 2. Shows the polar spindle centrosomes and the rounded chromosomes, one of which in fig. 3*a* has already opened into a ring. × 860.

Fig. 4.—Slightly later stage. Somewhat over-stained, so that the centrosomes appear very large. Their elongated form indicates their approaching division. × 860.

Fig. 5.—Uterine egg showing polar spindle and spermatozoon. The centrosomes have already divided. The centrosphere has acquired a distinct outline. × 860.

Fig. 6.—Spermatozoon (from an egg in the stage of fig. 5), one end of which is surrounded by the dark area which is less distinctly seen in fig. 5. × 860.

Fig. 7.—Recently laid egg. The polar spindle is still in a central position. The spermatozoon has contracted into the shape of a spindle. × 860.

Fig. 8.—First polar spindle after it has reached the surface of the egg. This specimen is unusual, as all the chromosomes still have the ring form. In this stage some of the rings at least have usually broken. × 1240.

Note.—Figs. 5, 7 and 8, as well as some that follow, illustrate the separation of the derived centrosomes, which in this species generally occurs in a longitudinal direction, parallel to the axis of the spindle or nearly so.

Figs. 9 and 10.—Chromosomes of eggs in the same stage as fig. 8. × 1240.

Plate XXXVII.

Fig. 11.—First polar spindle, introduced to show the chromosomes. × 1240.

Fig. 12.—Later stage of the first polar spindle. The centrosomes of the outer pole of the spindle, which is somewhat over-stained, lie in an oblique instead of the usual axial position. The centrosomes of the inner pole have begun to separate. × 860.

Fig. 13.—Formation of the first polar body. × 860.

Figs. 14, 15, 16.—Three stages of the second polar spindle, showing the reduction of the aster rays in strength and number, and the formation of the new spindle from the centrosphere. In the earliest of these (fig. 14), the chromosomes have already split into two segments. The chromosomes are more widely separated from each other than in the first polar spindle. Figs. 14 and 15 × 1240. Fig. 16 × 860.

Plate XXXVIII.

Fig. 17.—Final stage of the second polar spindle, showing the cell-plate. Most of the second polar body is in the next section. The chromosomes have swelled up into vesicles. × 1240.

Fig. 18.—Sperm-nucleus from an egg in the stage of fig. 17. ×860.

Figs. 19*a* and 19*b*.—Somewhat later stage than fig. 17. The polar spindle aster has degenerated, its centrosome and centrosphere have vanished, and the rays become very indistinct. The vesicles are larger and each contains a nucleolus. The sperm-nucleus and several of the female vesicles appear in fig. 19*b*, which is another section of the same egg. ×860.

Figs. 20 and 21.—Show the fusion of the vesicles into the female pronucleus, the remains of the second polar spindle aster and the male pronucleus. The latter lies unusually far from the center of the egg in fig. 20. ×860.

Note.—Figs. 19 and 20 show the difference in the condition of the chromatin in the first and second polar bodies. In fig. 19*a* the first polar body lies on the right, in fig. 20, on the left.

Fig. 22.—Very early stage of the first cleavage spindle, showing the first appearance of the cleavage centrosomes. The female pronucleus, which is three-lobed, lies above; the male, below and to the right. Threads of chromatin, which will develop into the chromosomes of the cleavage spindle, are beginning to be noticeable. ×860.

Plate XXXIX.

Fig. 23.—A rather early stage of the first cleavage spindle. The threads of chromatin can be seen in the pronuclei, but their membranes are still complete or nearly so. The centrosomes are not stained. ×860.

Fig. 24.—First cleavage spindle, shortly after the disappearance of the pronuclear membranes, which have dissolved while the pronuclei were still some distance apart. Two groups of chromosomes are shown, derived from the male and female pronucleus respectively. The centrosomes are not stained and the centrospheres are poorly preserved, showing an outer ring not normally present. ×860.

Fig. 25.—First cleavage spindle fully formed. ×860.

Fig. 26.—Late stage of the same showing the centrosomes of one pole only. The single centrosome shown in each pole in fig. 25 has divided into two, which separate in a direction transverse to the axis of the spindle. The centrosphere is more differentiated than in the earlier cases, as it is in the later stages of the polar spindles also. ×860.

Figs. 27*a* and 27*b* —Early stage of the second cleavage spindles. One aster, lying in the next section, is shown in fig. 27*b*. ×860.

Plate XL.

Fig. 28.—Second cleavage spindles. The U-form of the chromosomes can be seen in the right hand blastomere. The centrospheres exhibit the same defect described in fig. 24. ×860.

Fig. 29.—Two cells of an egg in the four cell stage with third cleavage spindles. ×860.

Fig. 30.—Process of forming the first polar body. Outlines of the forms assumed by the polar body in one instance in the course of ten minutes.

Fig. 31.—Outline of a spermatophore. The small part only is inserted through the opening made in the epidermis.

Fig. 32.—Embryo about eight days old endeavoring to escape through an opening accidentally torn in the egg membrane. Ventral surface of embryo shown. ×285.

Fig. 33.—Embryo about eight days old, prematurely hatched by tearing the egg membrane. × about 285.

Fig. 34.—Embryo a few days after hatching. × about 285.

Fig. 35.—Embryo a week after hatching. × about 285.

Plate XLI.

Fig. 36.—*Planocera nebulosa.* Uterine egg showing a first polar spindle. This is peculiar in that all the chromosomes have already assumed the elongated form, the rings having broken at one point. A part of the spermatozoon is seen to the right of the spindle. ×860.

Fig. 37.—*Planocera nebulosa.* Beginning of the second polar spindle. In this specimen the centrosomes are separating in a direction nearly transverse to the axis of the spindle. ×860.

Fig. 38.—*Planocera nebulosa.* Egg in a little earlier stage than the last, yet the second polar spindle is further advanced. Near it is the sperm-nucleus, in this case rather larger than usual at this stage, and in the upper right hand part of the section the sperm-aster, whose centrosome appears very large owing to insufficient extraction of the stain with the alum solution. ×860.

Fig. 39.—*Planocera nebulosa.* Sperm nucleus and aster from an egg in the second polar spindle stage. The centrosome has just divided, and the centrosphere has become elongated. ×1240.

Fig. 40.—*Planocera nebulosa.* Second polar spindle more advanced than in fig. 38. Most of the chromosomes lie in another section. Near the spindle the sperm-nucleus, and to the left, near the edge of the section, the sperm-aster is shown. The latter has proceeded somewhat farther in its division than the one shown in fig. 39. ×860.

Note.—Figs. 36, 38 and 40 show the position of the spermatozoon and later the sperm-nucleus very near the center of the egg and the polar spindles, which is so common in this species as to be quite characteristic.

Fig. 41.—*Planocera or Eustylochus.* Diagram showing successive stages in the division of a chromosome of the first polar spindle.

Fig. 42.—The same, showing another method of division.

Fig. 43.—Diagram showing different degrees of modification (not different stages, as in the last two figures) of one of the forms of chromosome of the first polar spindle.

Fig. 44.—*Eustylochus ellipticus.* Entire egg in two cell stage. ×285.

Figs. 45 and 46.—Same in four and eight cell stages respectively, seen from the vegetative pole. ×285.

VII.—North American Ophiuroidea. I.—Revision of certain Families and Genera of West Indian Ophiurans. II.—A Faunal Catalogue of the known Species of West Indian Ophiurans. By A. E. Verrill.

Part I. Revision of certain Families and Genera of West Indian Ophiurans.

The numerous shallow water Ophiurans of the West Indian faunal region have been pretty fully studied by several authors,* so that most of the species are fairly well known, and many of them are to be found in most of the larger museums. Nevertheless there is no recent or fairly complete faunal list of the species.

The deep-sea species are also very numerous. These have been collected in large numbers by scientific explorations carried on by the U. S. Coast Survey Steamer "Blake," under the supervision of Mr. Alexander Agassiz, and by earlier explorations, under the supervision of Mr. L. F. de Pourtales. A number of deep-sea species were also dredged, in the same region, by the "Challenger." All the U. S. Coast Survey collections and those made by the "Challenger" were worked up and reported upon by Mr. Theodore Lyman in a number of important reports.†

The large collections from this region made by the U. S. Fish Commission steamer "Albatross" were also studied by Mr. Lyman, but no report upon them has yet been published.

During the present year the writer has published a report‡ on a small but interesting collection obtained by a scientific expedition to

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*Lütken, Addit. ad Hist. Ophiur., Part II; Synop. gen. Ophiur. ver.. 1869.

Lyman, North Amer. Ophiuridæ, Ill. Catal. Mus. Comp. Zool., I. 1865.

Ljungman, Ophiuroidea viv. hucusque cognita enumerat, Ofvers. Kgl. Vetenskaps-Akad. Forhandlingar, for 1866, 1867.

†Bulletin of the Mus. Comp. Zoology, Vol. I, No. 10, p. 309, 1869; Vol. V, No. 9, p. 217, 1878; Vol. X, No. 6, 1883; also Vol. V, No. 7, p. 67, 1878, and Vol. VI, No. 2, 1879 (Challenger Coll.).

Illust. Catal. Mus. Comp. Zool., Vol. VI, 1871; Vol. VIII, No. II, 1875.

‡Report on the Ophiuroidea collected by the Bahama Exped., 1893, Nat. Hist. Bulletin, Univ. of Iowa, Vol. V, pp. 1–86, Plates i–viii, 1899.

the Bahamas and Cuba from the University of Iowa, under the direction of Prof. C. C. Nutting. This collection included only such species as were obtained in less that 260 fathoms.

The present revision and list is based on several collections that I have studied, but mainly on the following :

I.—The general collections of the Peabody Museum of Yale University, in which is included a series of authentically named West Indian species, sent by Dr. Chr. Lütken, from the Museum of Copenhagen, many years ago.

II.—A pretty full series of deep-sea species dredged by the "Blake" and named by Mr. Lyman, sent by the Museum of Comp. Zoology.

III.—The collection made by the Bahama Expedition from the University of Iowa, referred to above.

IV.—The extensive collection made by the U. S. Fish Commission steamers "Albatross," "Fishhawk," and others, under my own supervision, in every year from 1871 to 1887, along the American coast north of Cape Hatteras, and including many deep sea species.

Only a small proportion of those in this last named collection appear to reach the West Indian faunal area, and therefore only a few of the species will be mentioned in this article. A special article on the Ophiurans of the north-eastern coast is, however, well advanced towards completion and will be well illustrated.

In the first part of this paper, I have endeavored to revise some of the larger and more difficult genera and families, and to supply analytical tables, so as to enable students of this group to identify the species without expending such a great amount of time as has been necessary hitherto. The Amphiuridæ and Ophiacanthidæ have, therefore, received here more attention than other groups, for they are always the most difficult to deal with.

In this article I have generally used the same names for the organs and parts that were used by Mr. Lyman in his various works on this group, but have made a few changes. I have preferred to use *oral shield* instead of "mouth-shield," *adoral shield* instead of "side-mouth-shield," and *oral papillæ*, in place of "mouth-papillæ." In the genera allied to *Amphiura*, I have usually called the "outer mouth-papillæ" or papillæ of the second oral tentacle, the *distal oral tentacle-scales* to indicate their homology with the ordinary tentacle-scales. The same idea has been carried out in *Ophiacanthidæ*. In the latter group I have designated the apical "mouth-papillæ" as *tooth-papillæ*.

Class OPHIUROIDEA.

Order I. **OPHIURÆ** Müller & Troschel, 1842.

Ophiuræ Ljungman, Oph. Viv., p. 303, 1867. Verrill, 1899*a*, p. 4.
Ophiuridæ Lyman, and many other authors.
Zygophiuræ and *Streptophiuræ* Bell, 1892.

Family, **PECTINURIDÆ** Verrill, 1899.

Ophiodermatidæ Ljung., Oph. Viv., p. 87, 1867. Lutk., Addit. Hist. Oph., iii, p. 87, 1869.
Pectinuridæ Verrill, Nat. Hist. Bull. Univ. of Iowa, v, p. 4, 1899*a*.

The generic name, *Ophioderma*, is now recognized only as a synonym of *Ophiura*. Therefore I have changed the name of this family, as is customary in such cases. The name *Ophiuridæ* cannot properly be used for the family group here included, because Mr. Lyman and many others have always used it to designate the order *Ophiuræ*, or all the *Ophiuroidea* exclusive of the *Euryalæ*.

Family, **OPHIOLEPIDÆ** Ljung., 1866.

Ophiozona nivea Lyman.

Ophiozona nivea Lyman, Illust. Catal. Mus. Comp. Zool., vol. viii, p. 8, figs. 85-86, 1875; Bull. Mus. Comp. Zool., vol. v, p. 128, 221; Three Cruises of the Blake, ii, p. 110, fig. 390, 1888.
Ophiozona nivea, var. compta Verrill, Nat. Hist. Bull., v, p. 9, pl. iii, fig. 2, 1899.

Variety, **compta** Verrill.

Plate XLIII. Figures 1, 1*a*.

The varietal name was given to the variety with distinctly separated radial shields, regardless of the variations in the oral shields, which happen to be, in both the specimens figured (pl. xliii, figs. 1 and 1*a*) of the shorter and more ovate form.

A study of a series of specimens sent to me by Mr. Lyman (from sta. 291, 200 fath., Blake Exp.) shows considerable variation in the form of the oral shields. These are sometimes oblong, twice as long as broad, with the outer and inner portions of the same width; in other cases the outer part, beyond the lateral indentations caused by the end of the genital slit, is broader than the inner part; in other specimens the outer part is narrower than the inner. The

number and arrangement of the large angular plates outside the oral shields are variable even on the same specimen. Usually there are three or four of the larger plates, of which two stand side by side, near the margin of the disk.

The radial shields are often separated distally by a row of two or three small angular plates and a large proximal plate as in our figure (pl. XLIII, fig. 1), but in other specimens the radial shields are in contact distally, but separated proximally by a single large triangular plate, as in Mr. Lyman's type-specimen of *O. nivea*. The central disk-plate is usually closely surrounded by five large angular plates, but in many cases there are small plates intervening more or less irregularly. The variations in the scaling of the disk and in the radial shields are not coincident with the variations of the oral shields.

This species is allied to *O. tessellata*. It is easily distinguished by the large, irregular disk-plates, wide, oblong, oral shields ; three subequal arm-spines, low down on the sides. There are no marginal spinules outside the radial shields. The upper arm-plates also differ in form.

Off Havana, 110 to 263 fathoms (Bahama Exped.). Taken by the Blake Exped. in 56 to 424 fathoms; off Barbadoes, 200 fath. (Blake Exped.).

Family, **OPHIOTHRICHIDÆ** Ljung.

Ophiothricidæ Ljung., Oph. Viv., 1866.
Ophiothrichidæ Lütken, Addit., iii, 1869. Verrill, Bahama Exped., p. 18, 1899.
Ophiothrichinæ Ljung., Joseph. Exp., 1871.

The family is characterized by the well defined group of true tooth-papillæ ; by the absence of oral papillæ ; by the usually numerous, long, slender, generally rough and glassy arm-spines; and internally by the complex, interlocking articulations of the arm-bones, and the strong mouth-frames and large radial shields. The peristomial plates, in the typical genera, are in three parts ; of these the middle one is large, like an oral shield. The dental plate or apical jaw-plate is a separate piece.

This family, as now limited, includes the following genera: *Ophiothrix*, *Ophiothela*, *Ophiocnemis*, *Ophiopsammium*, *Ophiomaza*, *Ophiogymna*, *Ophiocampsis* Duncan, *Ophiotrichoides* Ludw., *Ophiopteron* Ludw., *Lutkenia* Brock, *Gymnolophus* Brock, *Ophioœthiops* Brock, *Ophiosphærea* Brock, and *Ophiolophus* M. Tanner.

The more typical of these genera have the disk-scales covered with slender rough spinules, but the number and length of the spinules may vary considerably, even in the same species of *Ophiothrix*. Some of the genera have only granules on the disk-scales, and others have naked scales, and some even smooth skin.

Nearly all the genera and species of this family live clinging closely to various sponges, gorgonian corals, crinoids, hydroids, or even to other ophiuroids. Many of them are more active in their movements than is usual among *Ophiuroidea*, and many are bright colored when living.

The genus *Ophiopteron* Ludw. is very remarkable for having a broad membranous web between the arm-spines, and is supposed to be a free-swimming form. It is from Amboina.

The species of this family are mostly found in the warmer seas and in shallow water, and they are most abundant and most diversified in the East Indies. Brock enumerated fifty-six species of this family from the Indo-Pacific region and considerable additions have been made to the list by later writers. Several of the genera are known only from the East Indies or Australia. *Ophiothrix* is the only West Indian genus.

Family, **AMPHIURIDÆ** Ljung., 1867 (emended).

Amphiuridæ Verrill, Oph. Bahama Exp., Nat. Hist. Bull. Univ. of Iowa, v, p. 23, 1899.

In the report on the *Ophiuroidea* of the voyage of the Challenger, Mr. Lyman, 1882, recognized about ninety species of *Amphiura*. In subsequent papers by him and others, about thirty additional species have been described. This very extensive assemblage of species is evidently capable of being divided into several natural groups, in addition to the several minor groups already separated by Mr. Lyman and others. Mr. Ljungman, as long ago as 1867, set off a large number of species as a natural generic group, under the name of *Amphipholis*. At a still earlier date, Lütken had indicated this and other natural sections of the genus, without naming them.

Mr. Lyman, however, did not recognize *Amphipholis* and some other good divisions in any of his works, except as sections of the genus.

The contrast between the structure of the mouth in typical *Amphipholis* and typical *Amphiura* is very striking. The oral papillæ in the former can close up the mouth-slits tightly, acting like oper-

cula; while in the latter the few slender and widely separated mouth-papillæ cannot close the slits, but always leave them widely open. This difference is doubtless directly correlated with important differences in their mode of feeding and nature of their food.

Subdivisions of Amphiura.

The species of *Amphiura*, as adopted by Lyman, mostly fall into four large groups, which seem to be natural divisions of generic value. They are best characterized by the structure, number and arrangement of the mouth parts, as in most other ophiuran families. A few aberrant species, not found in American waters, must be referred to additional groups (V, VI, etc.).

I. *Amphiura* (restricted). Type, *A. Chiajei* Forbes.

One apical or subapical oral papilla. One (rarely two) small, distal papilla (oral tentacle-scale); middle of jaw-edge without papillæ; mouth-slits gaping. Four to seven or more (rarely three) arm-spines. Radial shields divergent.

II. *Amphipholis* (restricted). Type, *A. squamata* (or *A. elegans*.)

Two small lateral oral papillæ and one broad, operculiform, distal one, forming a continuous series along the entire jaw, and capable of nearly or quite closing the mouth-slits. Radial shields in close contact.

III. *Amphiodia* Verrill, 1899*a*. Type, *A. pulchella* (Lym.).

Three (rarely four) small subequal oral papillæ, none of them operculiform; they form a regular series, attached mostly to the side jaw-plate. No distal oral tentacle-scales. Three (rarely four) arm-spines. Radial shields often more or less joined.

IV. *Amphioplus* Verrill, 1899*a*. Type, *A. tumida* (Lym.).

Four or five small unequal oral papillæ, none operculiform, usually arranged in a discontinuous series, of which the outermost, at least, arises from the adoral shield and is really a distal oral tentacle-scale. Arm-spines three (rarely four). Radial shields generally quite separated. Disk scales naked.

V. *Paramphiura* Kœhl. Kœhler has recently established a new genus, *Paramphiura*, for *A. punctata* Forbes and *A. bellis*, var. *tritonis* Hoyle.

It is distinguished by having a pair of large supplementary scales or plates, proximal to the adoral plates. There are two small oral papillæ.

VI. *Ctenamphiura* Ver., gen. nov. Another special group is represented by *A. maxima* Lym.

It has three oral papillæ in a series, of which the middle one is very large and flat, and the outer one small and spiniform; the apical one is large. The mouth-shield is so large that it touches the first side-arm plate on each side, while the adoral shields are very small, not meeting within and not embracing the sides of the mouth-shield, as they do in all the other divisions of *Amphiura*. Two large tentacle-scales. Arm-spines very numerous, ten in the type. Upper and under arm-plates in contact. Disk scales coarse in the type. Radial shields separated.

The type, *C. maxima* (Lym.), is from the E. Indies in 28 fath.

Amphiura Forbes (restricted sense).

Amphiura Forbes, Trans. Linn. Soc., Vol. xix, pp. 149, 150, 1842 (type *A. Chiajei*). Ljungman, Ophiur. Viv., p. 318, 1867.

Amphiura (section B.) Lutken, Addit. Hist. Oph., ii, p. 114, 1859.

Amphiura (*pars*) Lyman, Bull. Mus. Comp. Zool., i, pp. 335, 338; Voy. Challenger, v, pp. 122, 124, 1882.

Amphiura (restr.) Verrill, Ophiur. Bahama Exped., v, p. 24, 1897.

Only one pair of true oral papillæ to each mouth-slit; they are placed on each side of the apex of the jaw. A single, usually spiniform, papilla, sometimes with a smaller one by its outer side, is situated on each side of the distal end of the mouth-slit, usually attached to the edge of the adoral shield. This is really the outer oral tentacle-scale.

Owing to the small number of oral papillæ and their peculiar arrangement, the mouth slits cannot be closed, but appear always gaping, more or less.

The edge of the jaw-plate, along its middle portion, is naked. Higher up in the mouth-slit there is a small spiniform papilla, usually visible from below; this is the tentacle-scale of the first oral tentacle. It is often shown in published figures as if it were a true oral papilla. Tentacle-scales usually one or two, sometimes lacking (section *Ophiopelte*).

Arm-spines short, usually four to seven or more, rarely three. Radial shields naked, small, generally divergent, with the distal ends either in contact or somewhat separated by small scales. The disk is usually covered with small naked scales.

In one group the under side is without scales (*Hemilepis*).

In a group referred by Lyman to *Ophiocnida*, the disk is covered with small spinules, but as the mouth-parts and other organs agree with typical *Amphiura*, it might better be regarded as a distinct genus, or else as a subgenus of *Amphiura*. To this I have given the name *Amphiocnida*. (See p. 316.)

The genus *Amphiura*, as here adopted, agrees nearly with the typical genus, as restricted by Ljungman in 1867. Mr. Lyman also stated that this should be the typical group, in case the genus were to be divided. This restricted genus still includes over sixty species, with a considerable diversity of structure, as the following table will show. The species are found in all seas and at all depths.

The arms are generally long and slender, tapering very gradually, and very flexible.

Many of the species, perhaps nearly all, live buried in the mud and sand of the bottom, or concealed in crevices or under stones, etc. When buried in the mud they usually project the tip of one or more of the arms above the surface of the mud.

This habit of living concealed is doubtless correlated with the absence of disk-spines for protection, and with the lack of special imitative colors.

Many of the species have plain, dull colors, resembling the color of the sea-bottom where they live. *A. Otteri*, from deep water, is plain salmon or light orange. Such colors are protective in deep water.

Amphiura (*restricted*): *Table of the species inhabiting the West Indies and adjacent waters, and the Atlantic Coast of North America.**

The characters given in this table are those of the *adult* specimens, or at least of the largest described and figured. The young specimens often have fewer arm-spines and differ in other particulars. The number of arm spines given is that of the fully developed joints, towards the base of the arms. The number of spines is also liable to vary in adult specimens. Characters not named in the table, such as the shape of the oral shields, radial shields, arm-plates, etc. are often of more value in determining the species than some of the characters mentioned, and should always be considered. They are not all easily utilized in a condensed table like this.

I.—Disk covered with naked scales.

A.—Tentacle-scales present. Radial shields divergent, their distal ends separated, or scarcely touching.

B.—Tentacle-scales two to a pore.

*In the table, the species that are entirely northern in their distribution are designated by an asterisk.

a.—Disk covered with scales above and below.

b.—Disk-scales thin and nearly even.

c.—Outer oral papilla flat or squamiform, usually with a small supplementary papilla by its side. Arm-spines 3 to 5, short and stout.

A. incisa Lym., '83. Arm-spines 3 ; radial shields wide. Disk-scales large.

A. Eugeniæ Ljung., '66. Arm-spines 4 or 5. Brazil.

cc.—Outer oral papilla spiniform, prominent.

d.—Arm-spines slender, tapered. Radial shield wedge-shaped, divergent.

e.—Arm-spines 4 or 5 ; lowest one longest, bent. Disk-scales minute.

A. complanata Ljung., '66. Brazil.

ee.—Arm-spines 6 to 8, nearly equal, two or three lower ones usually bent. Disk scales not minute, regular.

A. Otteri Ljung., '66. Maine to W. Indies, Portugal.

dd.—Arm-spines 5, short and stout, beaked. Disk-scales minute, obscure beneath. Radial shields narrow, touching distally.

A. Palmeri Lym., '82. West Indies.

bb.—Disk-scales irregular and swollen. Arm-spines 8. Outer mouth-papilla spiniform.

A. crassipes Ljung., '66. Brazil.

aa.—Disk naked beneath, or with rudimentary scales only. Radial shields narrow, elongated. *Hemilepis* Ljung., '71.

f.—Arm-spines 4 or 5, stout, subequal.

A. semiermis Lym., '69. W. Indies.

ff.—Arm-spines 6, tapered, lowest longest.

A. flexuosa Ljung., '66. Brazil.

BB.—Tentacle-scale only one to each pore. Arm-spines 3 to 6. Radial shields divergent, the distal ends sometimes touching, usually subovate or "pear-seed shape." A small supplementary papilla or "oral scale" often stands by the side of the outer oral papilla or oral scale.

g.—Oral shield transversely elliptical, rhombic, or quadrant-shaped, broader than long.

h.—Arm-spines 5 or 6, unequal, the lowest longest. Disk-scales minute, not in a rosette. Tentacle scale large, ovate. Oral shield elliptical. A supplementary oral scale is often present.

A. grandisquama Lym., '69. W. Indies.

hh.—Arm-spines 3, equal or subequal, tapered. Disk-scales not minute, forming a rosette. Tentacle scale small, flat. Oral shield quadrant-shaped. A supplementary oral scale is often present. Radial shields broad, in contact distally.

A. lunaris Lym., '78. W. Indies.

gg.—Oral shields longer than broad, oblong or ovate. Tentacle-scale minute. Arm-spines 3 to 5, short, subequal. Radial shields small, divergent.

i.—Disk-scales not minute, unequal, with edges rounded and serrulate, forming a rosette, oral shield small, subovate. Under arm-plates wide shield-shaped, little longer than broad.

* *A. Sundevalli* M. and Tr. Gulf of St. Lawrence.

ii.—Disk-scales minute, oral shields rather large, ovate. Under arm-plates oblong, much longer than broad.

A. Stimpsoni Ltk., '59. W. Indies.

AA.—Tentacle-scales absent or rudimentary.

j.—Disk destitute of scales below, or only partly covered. Radial shields divergent, pear-seed-shaped or wedge-shaped. = *Ophiopelte* Sars, Ljung.

k.—Arm-spines six or seven, short, straight. Disk-scales minute, not in a rosette.

l.—Arm-spines seven, lowest short and stout, others flattened, subequal. A supplementary outer oral scale. Oral shield obtusely angulated or convex distally and proximally. Dorsal arm-plates triangular, with the distal end very convex; five middle spines flattened and denticulated.

* *A. denticulata* Kœhl., '96. Off Newfoundland.

ll.—Arm-spines six, short. Oral shield acute-angled at both ends. Dorsal arm-plates broad, ovate.

A. Atlantica Ljung., '66. Off St. Helena.

kk.—Arm-spines three to five, slender, straight. Radial shields divergent.

m.—Arm-spines four or five, short. A rudimentary tentacle-scale sometimes present, usually wanting.

**A. fragilis* Verrill, '85. Arm-spines four or five, subequal, tips rough. U. S. East Coast.

mm.—Arm-spines three or four, equal, slender, straight. Radial shields small, touching distally, little divergent. Disk scales small, in rosette. Disk partly naked below.

* *A. exigua* Verrill, sp. nov. Gulf of St. Lawrence.

jj.—Disk entirely covered with scales below. Radial shields stout, largely joined, not divergent. Arm-spines three or four, equal, straight. Disk-scales rather coarse.

* *A. Canadensis* Verrill, sp. nov. Gulf of St. Lawrence.

II.—*Amphiocnida, gen or sub-gen. nov.* (see page 316).

Disk-scales bear small acute spinules. Arm-spines five to ten. Tentacle-scale usually absent. (No American species known.)

AMPHIPHOLIS Ljung. (restr.)

Type, *A. Januarii* Ljung.

Amphipholis Ljung., Ofvers. Kongl. Vet. Akad. Förhandl., p. 165, 1866; op. cit., p. 311; op. cit., p. 644, 1871.

Amphiura (*pars*) Lyman, Illust. Cat. Mus. Comp. Zool., i, p. 115, 1865; Bull. Mus. Comp. Zool., i, pp. 335, 339, 1869; Voy. Chall., v., pp. 122, 125, 1882.

Amphipholis (restr.) Ver., Oph. Bahama Exped., v, p. 24, 1899.

Three or four oral papillæ form a continuous series along the whole edge of the jaw; of these the distal one is attached more or less to the adoral shield and is operculiform or flat, and often much broader than the others. The two inner are usually small and conical. Disk generally covered with naked scales, but in one species bearing a few spines (Sec. AA). Radial shields naked and usually in close contact along the whole or most of their length. Arm-spines generally three (rarely four), small, slender, tapered. Tentacle-scales one or two, sometimes none.

In the more typical species the arms, though slender, are rather short and not very flexible, but in some others they are long, slender and very flexible.*

Table of the species of Amphipholis and Amphiodia from the West Indian region, including Brazil, and from the eastern coast of North America.

I.—*Amphipholis* Ljung.

Three (rarely four) oral papillæ; outer one operculiform or broad and flat, arising partly from the adoral shield. Radial shields joined.

A.—Disk covered with naked scales.

a.—Three arm-spines, rarely four, on basal joints.
b.—Arms of moderate length.

**A. elegans* (Leach) Ljng.	Europe, America.
A. tenera (Ltk.) Ljng.	W. Indies.
A. tenuispina Ljng.	N. Atlantic.
A. limbata (Grube) Ljng. Dorsal plates wide, short.	Brazil.
A. subtilis Ljng. Radial shields long and narrow.	Brazil.

bb.—Arms long and slender.

A. Goësi Ljng.	W. Indies.

aa.—Four or five arm-spines. Arms very long and slender. Radial shields long and narrow. Oral shields large, obovate. Adorals narrow. Outer oral papillæ very broad.

A. gracillima (Stimp.) Ljng.	S. Carolina.

AA.—Disk-scales with small, scattered spinules. Two small tentacle-scales. Radial shields in contact for half their length. Three arm-spines.

A. abnormis (Lym. '78, as *Ophiocnida*).	W. Indies.

* Among foreign species of this genus are the following: *A. squamata*, Europe; *A. Torelli*, Iceland; *A. Pugetana*, *A. violacea*, *A. microdiscus*, *A. Puntarenæ*, *A. geminata*, the last five from the west coast of America; *A. Patagonica*, Magellan Str.; *A. Koehii* (Lym.) and *A. Coreæ* (Duncan), East Asia. The following have four oral papillæ; *A. impressa* Lj., E. Indies; *A. depressa* Lj. and *A. hastata* Lj., from S. Africa.

II.—*Amphiodia* Verrill, 1899*a*. (See p. 316.)*

Oral papillæ three, rarely four, subequal, or the outer one is smallest, forming a regular series on the side of the jaw. Arm-spines three, rarely four. No distal oral tentacle-scale.

B.—Disk-scales naked.

c.—Two tentacle-scales.

d.—Radial shields rather wide, in contact at least distally.

A. Riisei (Ltk.) Ver. Oral shield elongate; adorals small, trigonal.

A. atra (Stimp.) Ver. Oral shield pelecoidal; adorals lunate, narrow. (Sometimes has four oral papillæ and four arm-spines.)

A. planispina (V. Mart.) Ver. Oral shield ovate, broadest proximally; adorals narrow, lunate. Brazil.

cc.—One tentacle-scale. Radial shields long and narrow, largely in contact.

e.—Disk with scales on the under side; on the upper side larger scales form a rosette. Arm-plates separated above and below. Oral shield obovate, smallest proximally. Adoral shield large, trigonal.

A. pulchella (Lym. '69) Ver. Florida.

ee.—Disk without scales below; no rosette above. Oral shield "spade-shape," with a distal lobe. Adoral shield broad triangular.

A. repens (Lym. '75) Ver. Florida.

BB.—Some of the disk-scales, near the margin or beneath, bear small spinules, or granules, or both.†

A. Lutkeni (Ljng.) Ver. West Indies.

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* *Amphiodia* is represented among extralimital species by a large series. Some are as follows. From west coast of America, five: *A. Barbarœ* (Lym.), *A. grisea* (Lj.), *A. urtica* (Lym.), *A. occidentalis* (Lym.), *A. Chilensis* (M. & Tr.), *A. Orstedii* (Ltk.), *A. antarctica* (Ljng.), Magellan Str.; *A. fissa* (Ltk.), Amoor; from the Indo-Pacific *A. ochroleuca* (Brock), *A. olivacea* (Brock), *A. impressa* (Ljng.), *A. Andreæ* (Ltk.), *A. lævis* (Lym.); from South Africa, *A. gibbosa* (Ljng.), *A. integra* (Ljng.)

† *Amphipholis Lutkeni* Ljng. and *Ophiocnida Loveni* (Ljng., Lym.) would, perhaps, go here, but they are so closely related to the type of *Ophiocnida* that I have referred to them under that genus (see p. 316).

Amphioplus, gen. nov. (See p. 306.)

Table of the species of Amphioplus from the West Indian region.

C.—Tentacle-scales present.

h.—Two tentacle-scales.

i.—Oral papillæ four to six, in a series; one or two are distal oral tentacle-scales. Arm-spines usually three, sometimes four.

j.—Dorsal and ventral arm-plates, at base of arms, in contact. Radial shields narrow, separated, or barely touching. Arm-spines three.

A. tumida (Lym. '78) Ver. Disk swollen ; radial shields linear. W. I., 321 fath.

**A. abdita* Verrill, '72. Radial shields lunate, parallel, middle arm-spine stouter, flattened, obtuse. Four oral papillæ. Long I. Sound.

**A. macilenta* Ver. Five oral papillæ. Spines all slender. East Coast U. S.

A. nereis (Lym. '83) Ver. Oral papillæ five, thick, unequal ; genital scale with a row of papillæ. W. I., 148 fath.

A. Agassizii Ver., p. 315. Oral papillæ six, slender, the two distal ones larger. W. I., 424 fath.

jj.—Dorsal arm-plates scarcely joined. Radial shields narrow and in contact distally. Five small, bead-like oral papillæ.

A. cuneata (Lym. '78) Ver. Three slender arm-spines. W. Indies.

ii.—Four (varying sometimes to three) oral papillæ. Arm-spines, three or four. Radial shields a little separated distally, divergent. Oral shield pelecoidal, acute proximally. Disk-scales do not form a rosette.

A. duplicata (Lym. '75) Ver. First under arm-plate often double; adoral shield narrow. W. Indies.

hh.—One tentacle-scale. Radial shields widely separated. Five unequal oral papillæ.

A. Stearnsi (Ives) Ver. W. Indies.

CC.—No tentacle-scale. Four oral papillæ. Four arm-spines. Radial shields touch distally.

A. Verrillii (Lym. '79) Ver. Radial shields rather large, divergent. Disk-scales form a rosette. W. Atlantic, 2650 fath.

Many extralimital species of *Amphioplus* have been described. Among them are the following :

A. canescens (Lym.) V., Pacific, 600 fath.; *A. glauca* (Lym.) V., Pacific, 345–420 fath.; *A. cernua* (Lym.) V., Pacific, 2300 fath.; *A. patula* (Lym.) V., Antarctic, 1975 fath.; *A. dalea* (Lym.) V., S. Atlantic, 2650 fath.; *A. lævis* (Lym.) V., Philippines.

Amphioplus Agassizii Ver., sp. nov.

Amphiura, sp., Lyman, Bull. Mus. Comp. Zool., vol. x, p. 253, pl. v, figs. 64–66, 1883.

Disk covered with minute scales, of nearly uniform size, not forming a central rosette. Radial shields narrow, separated by several rows of small scales. Oral shield obovate or pear-shape, evenly rounded distally, longer than broad, sides a little incurved. Adoral plate long, narrow, three-lobed, not meeting proximally. Oral papillæ six; of these the four inner ones are small, conical; the two outer are larger and broader and attached to the adoral plate.

Arm-spines three, slender, tapered. Tentacle-scales two, rounded. Under arm-plates are wider than long, broadly in contact and truncate at both ends. Upper arm-plates are broadly triangular, short, barely in contact.

This species, which was well figured by Mr. Lyman, but not named, is allied to *A. nereis*, but the latter has only five oral papillæ, of which four are stouter and blunter, while the outer one is minute; its oral shield is rounder; its under arm-plates are barely in contact, and have an inner angle; its arm-spines are larger and its disk-scales are also rather larger.

West Indies, 116 fath., Blake Exp.

Ophiocnida Lyman.

Subdivisions.

That this genus, as recognized by Mr. Lyman in his later works, is a heterogeneous group has been noticed by more than one writer. Mr. Lyman, himself, intimated as much in the Voyage of the Challenger. According to his view no difference exists between this genus and *Amphiura* except that *Ophiocnida* has spines or grains on the disk. But some of the species have only a few granules, while at least one species that he referred to *Amphiura* (*A. Lutkeni*) also has some small spinules on the disk, so that this distinction seems to be of little real value, taken by itself.* But as Mr. Lyman

* The same holds good in other cases. Thus *Ophiacantha* in some species has only granules, and *O. lævipellis* often has naked scales. (See p. 343.) In *Ophiothrix* similar variations are found.

included in *Amphiura* four groups that differ in their mouth-parts so widely that I have been led to separate them as genera, he naturally admitted the same variations in the mouth-parts of *Ophiocnida*. In fact we find in this group, as he finally left it, four divisions corresponding to the four divisions of *Amphiura* in structure of the mouth. They should be separated, therefore, if those of *Amphiura* are to be separated.

When originally constituted the genus included only two species. These are much alike and agree in mouth-parts. They have three subequal, true oral papillæ, arranged as in the division of *Amphiura* that I have called *Amphiodia*, to which they are in every way closely allied. It is, in fact, rather doubtful whether these two groups might not be united into a natural genus. In that case the variations in the covering of the disk might be considered as of merely sectional value.

But if we restrict *Ophiocnida* to the species having the characters of the types, they form a natural and easily recognizable group, which it is well, so far as known at present, to keep distinct. Mr. Ljungman gave the name *Ophiocnidella* to this typical group.

The second group, of which *O. Putnami* may be taken as the type, agrees with typical *Amphiura* in its mouth-parts, having but a single true oral-papilla, placed at the tip of the jaw, on each side, and one or two pairs of oral tentacle-scales at the distal corner. I have been inclined to consider this as a subgenus of *Amphiura*, for which I have proposed above (p. 307) the name *Amphiocnida*. It is, at any rate, very closely related to *Amphiura*. A study of its internal skeletal plates may hereafter show distinctions of more evident generic value.

The third group includes, so far as I know, only *O. abnormis* Lym. This agrees so completely in its mouth-parts, spines, etc. with typical *Amphipholis*, that I do not hesitate to unite it with that genus, considering the sparingly spinulose disk as merely of sectional value. (See p. 313.)

Another group, *Amphilimna*, having *O. olivacea* as its type, has more numerous oral papillæ and arm-spines, and a generally robust structure quite unlike the typical forms. Although corresponding with *Amphioplus* in the number of oral papillæ, this group seems to have special characters worthy of generic rank.

The following synopsis will give the principal characters of the three more important divisions discussed above, and of most of the described species :

Ophiocnida Lym., 1865 (restr.). Type *O. hispida* Lym., 1865.

Ophiocnida Lym., Ill. Catal. Mus. Comp. Zool., i, p. 133, 1865; *pars*, Voy. Challenger, p. 152, 1882.

Ophiocnidella Ljung., Ofv. Kongl. Vet. Akad. Förhandl., vi, 1871, p. 649 (Type *O. scabriuscula*).

Oral papillæ three, subequal, arranged in a series along the jaw-margin. Disk-scales distinct, bearing spinules or granules. Arm-spines three to five. Radial shields divergent. Two tentacle-scales; rarely one.

A.—Disk with numerous acute spinules.

a.—Arm-spines three, rarely four.

O. hispida (LeC.) Lym. '65. Spines three. Disk with many slender sharp spinules. Panama.

O. scabriuscula (Ltk.) Lym. '65. Spines three. Disk spinose. Disk-scales thick. Oral papillæ blunt, nearly equal. W. Indies.

O. echinata Lym. '74. Spines four. Disk very spinose. Adoral shields trigonal. Radial shields narrow. E. Indies.

O. sexradia Duncan. Six rays; four arm-spines; one tentacle-scale. E. Indies.

aa.—Arm-spines five or six.

O. scabra Lym. '79. Lowest spine thick and rough. Proximal oral papilla apical and bead-like. Adoral shield lunate. Off Bahia, 1275 fath.

AA.—Disk-scales partly bare; partly with granules or very short spinules, or both.

b.—Disk-scales large, in a rosette, mostly naked; some marginal and submarginal bear granules. Three arm-spines.

O. filogranea Lym. '75. Radial shields wide, divergent. Adorals lunate. Two tentacle-scales. Florida.

bb.—Disk-scales smaller, many naked; some marginal and submarginal bear grains or small conical spinules.

O. Loveni (Ljng.). Disk-scales in a rosette; some at margin, bear spinules; others below, bear granules. Outer oral papilla flat. Radial shields touch distally. Rarely four arm-spines. Brazil.

O. Lutkeni (Ljng. '71). A few submarginal and marginal scales bear small spinules. Three arm-spines. Dorsal arm-plates wide, usually broken into two or more parts. W. Indies.

Amphiocnida, gen. nov. = *Ophiocnida* (*pars*) Lym.

Disk-scales bear small acute spinules. Apical oral papilla small. Distal oral papilla (oral tentacle-scale) acute, spiniform. Middle of jaw-margin naked. Arm-spines five to ten. Typical species have no tentacle-scale.

A. Putnami (Lym.). Arm-spines nine to ten, stout, upper one clavate. Radial shields separate. No tentacle-scale. Hong Kong.

A. pilosa (Lym.). Arm-spines five to six, slender, tapered. Adoral shields trilobed. Radial shields, little separate. No tentacle-scale. Bass Straits.

A. alboviridis (Brock). Arm-spines five to six. No tentacle-scales. E. Indies.

A. brachiata (Mont.). Arm-spines seven to ten, flattened, one with an apical cross-piece. Europe.

Amphilimna Verrill. Type, *A. olivacea.*

Amphilimna Verrill, Ophiur. Bahama Exp., v, p. 30, 1899.

Oral papillæ four or five in a series. Tooth papillæ two to four. Arm-spines six to ten, of moderate length. Tentacle-scales usually two, spiniform, one each side of the tentacle-pore. Disk swollen dorsally, with a notch over the base of each arm, and covered with spinules. Radial shields parallel, largely in contact. This genus includes, besides the type, only *A. Caribea* Ljung.

Amphilimna olivacea Ver.

Ophiocnida olivacea Lyman, Bull. Mus. Comp. Zool., i, 10, p. 340, 1869; Ill. Cat. Mus. Comp. Zool., vi, pl. i, figs. 7, 8; Bull. Mus. Comp. Zool., v, 9, p. 227; op. cit., x, p. 253. Verrill, Amer. Jour. Sci., vol. xxiii, p. 219; Ann. Rep. U. S. Fish Com., vol. x, p. 661; op. cit., vol. xi, p. 549. Lyman, Report Voy. Challenger, Zool., *Ophiuroidea*, v, p. 156, 1882.
Amphilimna olivacea Ver., Ophiur. Bahama Exped., v, p. 30, 1899.

Plate XLII, Figures 1, 1*a*.

Arm-spines nine or ten; oral papillæ four or five.

Taken by the U. S. Fish Commission at numerous stations off the east coast of the United States, from off Martha's Vineyard to Cape Hatteras, in 63 to 192 fathoms, and by the "Blake" from off Rhode Island to the West Indies, in 40 to 126 fathoms. Off Key West, Florida, 75 to 80 fath. (Bahama Exp.).

A. Caribea (Ljung.) Ver.

Arm-spines six, rough. Oral papillæ four, the two distal ones squamiform.

It is possible that this species, from the West Indies, 300 to 400 fath., is the young of *A. olivacea*. In that case the latter name would become a synonym.

Family, **OPHIACANTHIDÆ** Ver.

Ophiacanthinæ (sub-family of *Amphiuridæ*) Ljungman, 1866; Lütken, 1869.
Ophiacanthidæ Verrill, Ophiur. Bahama Exped., Nat. Hist. Bulletin, v, p. 34, 1899.

The family is characterized by the prominent and highly developed side arm-plates, usually meeting above and below, and by the numerous, usually long, and more or less rough spines, which stand out nearly at right angles to the arm. The spines may be solid or hollow, glassy or opaque, terete or flat.

The oral papillæ are usually rather numerous and form a continuous row along the sides of the jaws, but the outer ones may be of larger size or different in form from the others, or clustered, and in such cases they are really the distal oral tentacle-scales. There may be only a single apical tooth-papilla, or there may be two or three, and sometimes there is a large cluster. The first under arm-plate is usually concave or somewhat bilobed within the mouth-slit, and usually bears two vertical flat processes, which sometimes become movable, like oral papillæ.

In some cases the outer oral tentacle-pore is exposed to view on the outer margin of the jaw, and then it has one, or sometimes several, special oral scales or papillæ by its outer side, or partly surrounding it. Some of its scales may be attached to the adoral plate, or even to the first under arm-plate. This plate is usually concave or somewhat bilobed, and usually bears two inner, lateral, scale-like processes, which are sometimes movable and papilliform like oral papillæ.

There is generally a single median acute tooth-papilla at the tip of the jaw, but there may be two or three, and in some cases (*Ophiocamax*, *Ophiomitra*, *Ophiotrema*) there may be a cluster of several spiniform tooth-papillæ. These were counted as oral papillæ by Mr. Lyman, but when they stand on the dental plate they should be considered as true tooth-papillæ.

The teeth are stout, flattened, obtuse; they vary from three to eight in number.

The internal structure of the mouth-parts and arms is much like that of some of the *Amphiuridæ*. The "jaw-plate" or dental plate is generally separate from the jaws, and the three parts of the peristomial plates are generally distinct, but they are united in *Ophiocamax*.

The genera *Ophioplax* and *Ophiolebes* are, in several characters, more or less intermediate between the two groups, both externally and internally.

This family, as here understood, includes the following genera: *Ophiacantha*, *Ophiomitra*, *Ophiotrema*, *Ophiocamax*, *Ophiolebes*, *Ophiothamnus*, *Ophiocopa*. *Ophiochiton*, *Ophiotoma*, and probably *Ophioblenna*. To these I have recently added several others, enumerated below, separated from *Ophiacantha*, *Ophiomitra*, and *Ophiopsila*.

The first six of those named above have the disk covered with scales bearing spinules or thorny processes, or sometimes granules. *Ophiochiton* and *Ophiocopa* have naked or nearly naked scales. *Ophioblenna* and *Ophiotoma* are covered with naked skin. The radial shields may be large or small, concealed or exposed.

Ophiacantha Müll. and Troschel, 1842. (*sens. ext.*)

The species of this genus, taken in the extended sense, are very numerous in all seas and are difficult to determine. They are abundant in deep water in northern latitudes, as well as in tropical seas. Ten or eleven species are known off the coasts of New England and Newfoundland. Several of them occur only at great depths. About twenty species, including two described as new in this article, are known from the West Indian fauna.

This genus is very remarkable for the great variations in the armature of the disk. Some species have only rounded granules; others well-formed tapered spines; others short, thorny stumps; others small bifid or trifid spinules or crotchets; while many species have mixtures of two or more of these sorts.

It is probable that these structures have been developed as protective organs, in accordance with the ordinary laws of Natural Selection, and that they are, therefore, directly correlated with the habits of the various species. But the habits of many species are not yet known. I have found several species clinging to gorgonian

corals, or lodged among their branches; others have occurred on hydroids; certain species, like *O. fraterna* and *O. bidentata*, often occur in vast numbers in the dredge where the bottom is composed of broken shells, covered with hydroids, sponges, crinoids, etc., among which they evidently find shelter; some species, as *O. gracilis* and *O. pentacrinus*, cling closely to crinoids.

It seems, therefore, that most of the species live more or less exposed to the attacks of fishes and other active enemies, against which a covering of sharp spines would afford some protection. But as fishes avoid coral-animals and hydroids, on account of their stinging powers, it might be expected that those species living among the branches of such organisms would require less protection by spines than those that merely conceal themselves, more or less, among the debris of the sea-bottom. A more careful study of the habits of the shallow-water species may determine, hereafter, whether such differences in habits have determined the evolution of the spines of the disk.

As for the long arm-spines, characteristic of most of the species of this and allied genera, they appear to have been developed in nearly all genera that habitually live exposed,* while those genera that live buried in the mud or sand, like *Ophioglypha*, *Ophiomusium*, *Amphiura*, *Amphipholis*, etc., or securely hidden in crevices or under stones, generally have short arm-spines.

Some of the species of *Ophiacantha* are brilliantly phosphorescent when first caught. I have myself observed this to be the case with *O. bidentata*, *O. fraterna*, and others. It may, very likely, be a peculiarity of the deep-water species, if not of all the others.

Owing to the difficulties in the way of the ready identification of the species, I have prepared the following analytical tables, which ought to aid materially in locating any of them, if the specimens be full grown, or nearly so. The young often differ considerably from the adults in the number and roughness of the arm-spines, armature of the disk, etc. The number of arm-spines counted is that of the largest groups, near the base of the arms; farther out the number rapidly decreases. The number of oral papillæ often varies with age, and also individually, in many species, especially in those in which they are numerous and clustered. The number of tentacle-scales,

* The genus *Ophiothrix* is notable for the high development of its spines. The species usually live more or less exposed, clinging to sponges, gorgonians, etc., which they often closely imitate in color, but some species live in the internal cavities of sponges.

or the number of joints that have two pairs varies in some species according to age, the number of these parts and of the spines increasing in the older specimens. In very large specimens of small species there is often a tendency to develop extra oral-papillæ and tooth-papillæ, either above or below the regular series. The precise number of species cannot be considered as constant in any species, and must always be understood to vary within more or less definite limits. This character has been used in some of the analytical tables only because of its easy observation. The degree to which the larger basal rows of spines approximate dorsally is of more importance, though not invariable, and the character of the serrulations or thorns on the spines is of considerable value, though slightly variable, even in adult specimens. The spines are always rougher in the young specimens.

Moreover, in using the analytical tables, it must be remembered that some of the species have been described only from a single specimen* and that the amount of variation is still unknown, in certain deep-sea species, which have not yet been studied from the later and larger collections.

It is also to be noted that in the case of deep-sea species, especially those obtained by the "tangles," many of the delicate parts are liable to be broken or torn off, and in the case of tentacle-scales and oral papillæ they may leave no traces. When such parts are reproduced they may not appear in the same number or form as at first.

Such accidents may account for many cases where the different arms or different jaws of a single specimen present variations in their appendages,† as well as for specimens in which all the arms

* Mr. Lyman's custom was to describe all his new species from a single type specimen. Had his health remained unimpaired he would, doubtless, have revised more fully the large collections from the later Blake Expeditions.

† In a large lot of typical *Ophiacantha bidentata* one abnormal specimen shows curious variations in the mouth-parts, which may be due to the repair of damages. The number of regular oral papillæ on the different jaws varies from three to five. On some jaws there is a rudimentary, wart-like, distal one; in others it is as large as the next; on one jaw there is an extra, slender, clavate papilla, back of the first, on the lower face of the jaw; the distal papilla is thick, blunt, clavate, and usually somewhat triquetral; one jaw has two papillæ grown together for half their length; one has an extra papilla above the inner one, and of the same form. The tooth-papillæ vary in form and size, and from one to three in number; one jaw has a terminal pair; and on one jaw some of the teeth are split into two. The first arm-plate has a vertical process on

vary. These ophiurans are able not only to reproduce a whole set of arms, but the entire upper part of the disk itself may be lost and reproduced.

As for the species included in the following tables, I have personally studied nearly all of them, and the few that I have not seen are well figured by Mr. Lyman.

Dichotomous analytical table of the East Coast and West Indian species that have been referred to Ophiacantha (sens. ext.)

In this table I have arranged the species as nearly as possible in accordance with what seems to be their natural relations.

Those prefixed by an asterisk (*) are from the American coast north of Cape Hatteras. All others are from the West Indian fauna.

A.—Oral shields join the first side arm-plates. Adoral shields are entirely proximal to the oral shields.

B.—True *Ophiacantha.* Disk wholly, and radial shields mostly, covered with small crotchets, thorny stumps, or short spinules or granules, or with a mixture of these forms.

C.—Disk covered with small crotchets, or short thorny stumps, or short spinules, with no elongated spines nor granules.

d.—Arm-spines finely serrulated, or nearly smooth under a simple lens, usually long and tapered, hollow, not glassy.

e.—Opposite basal rows of arm-spines, in the adults, are closely approximate dorsally or nearly so.

f.—Oral papillæ form a simple row, the distal one being generally the largest.

* *O. bidentata* (Retz.). Disk with short, thick, rough, obtuse stumps and crotchets. Distal oral papillæ wider, truncate. Tentacle-scale single, obtuse.

* *O. aculeata* Ver. Disk with slender, thorny, stumps. Distal oral papilla wide, flat, mucronate at the corner. Spines eight or nine, nearly smooth. Tentacle-scale lanceolate, acute. Arm-spines not always approximate dorsally.

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each side, not movable. The large outer tentacle-pore is visible from below, when the distal papilla is removed. The first oral tentacle is far up in the distal part of the slit and has no papillæ. The uppermost tooth is longer and more pointed than the rest. There may be two clavate tentacle-scales on the first joint.

* *O. fraterna* Ver. When full grown the arm-spines usually closely approximate dorsally (see p. 321).

* *O. abyssicola* Sars. Spines six, short, nearly smooth. Disk covered with fine crotchets.

* *O. anomala* Sars. Six arms. Oral shields narrow, or acute. Disk-spinules short, thick, conical or obtuse, roughly serrulate or thorny.

ff.—The distal oral papillæ, or oral tentacle-scales, are clustered or form a double row; all spiniform. Tentacle-scale spiniform.

* *O. enopla* Ver. Arm-spines seven or eight, roughly serrulate. Disk covered with small, short, obtuse stumps, having several terminal thorns.

ee.—Basal rows of spines not very closely approximate dorsally. Oral papillæ in a simple row.

* *O. fraterna* Ver. Disk covered with very small thorny spinules and crotchets and some rough granules. Oral papillæ three, acute, spiniform. Arm-spines eight, serrulate. Tentacle-scale small, flat, subacute. Arm-spines, in large specimens, are approximate dorsally.

O. cosmica Lym. Disk with coarse thorny stumps having several points at the end. Oral papillæ three, stout, conical. Tentacle pores large, with one large scale. Upper arm-plates slightly joined at base of arms.

dd.—Arm-spines decidedly thorny or prickly, and usually glassy, mostly long and slender.

g.—Basal rows of spines approximate dorsally. Side arm-plates very prominent. Disk with small, slender crotchets or branched spinules.

O. aspera Lym. Arm-spines nine or ten, slender, very thorny. Disk covered with fine thorny crotchets and stumps, terminated by two to six points. Tentacle scale single, flat, larger at the end, and thorny or lobed.

* *O. millespina* Ver. Arm-spines ten, long, roughly serrulate. Disk closely covered with small, thorny or branched spinules.

O. pentacrinus Ltk. Arm-spines six, upper ones very slender, not very thorny. Disk with fine crotchets. Tentacle-scale single, small, flat. Distal oral papilla flat.

O. scutata Lym. Arm-spines eight to ten, long, decidedly thorny. Basal tentacle-pores with two flat scales; one, and spiniform, farther out. Three tooth-papillæ. Disk-scales covered with small, thorny crotchets. A pair of papillæ on first under arm-plate.

gg.—Basal rows of spines not closely approximate dorsally. Disk with short thorny stumps.

O. stellata Lym. Arm-spines seven, very thorny. Three conical oral papillæ. One tooth-papilla.

CC.—Disk entirely covered with tapered spinules or true spines, or having more or less of them mixed with granules or other structures, or else covered with granules only.

h.—Disk covered with spinules only, or else having spinules mixed with other structures, not granulated.

i.—Disk with spinules only or mainly.

j.—Dorsal rows of spines approximate dorsally.

**O. spectabilis* Sars. Arm-spines six to eight, serrulate. Disk with tapered spines and some small conical stumps. Tooth-papillæ and distal oral papillæ clustered.

jj.—Basal rows of spines not approximate dorsally.

k.—Arm-spines finely serrulate, not glassy. Tooth-papilla single. Oral papillæ in a simple row.

O. segesta Lym. Arm-spines tapered, nearly smooth. Disk-spines small, slender, smooth, mixed with few crotchets and thorny stumps. Tentacle-scale single, small, acute. Oral papillæ three, conical, all similar.

* *O. crassidens* Ver. Arm-spines short, stout. Oral papillæ and teeth large and thick, rough. Disk with small, acute, conical spinules.

kk.—Arm-spines thorny and glassy. Disk-spines slender, thorny, acute; several tooth-papillæ.

O. pectinula Ver. Outer edge of dorsal arm-plates with a row of small acute serrations. Several distal oral papillæ.

ii.—Disk bearing few tapered spines mixed with other structures. Rows of spines approximate dorsally.

l.—Disk covered with granules mixed with a few tapered spines. Arm-spines finely serrulate or nearly smooth.

O. vepratica Lym. Arm-spines eight, long, tapered. Oral papillæ three, conical. Tentacle-scale single, large, conical or spiniform.

ll.—Disk-spines elongated, mixed with crotchets or thorny stumps. Arm-spines more or less finely serrulate.

O. varispina Ver. Arm-spines eight, serrulate, translucent. Disk with thorny stumps and few acute spines. Tentacle-scale single, flat, subspatulate. Oral papillæ wide, flat, obtuse; distally there is often an extra marginal one.

hh.—Disk covered with small close granules alone. Basal rows of spines not approximate dorsally. Arm-spines serrulate; under arm-plates short and broad, separated.

* *O. granulifera* Ver. Arm-spines nine, the upper ones long and slender, finely serrulate, lower ones short, rough. Oral papillæ all spiniform. Tentacle-scale lanceolate, two on first joints.

BB.—Radial shields largely uncovered. Disk-scales either partially naked and easily visible, but bearing more or less granules or spinules, or else entirely concealed.

m.—Disk-scales largely exposed.

n.—*Ophialcæa* Ver., 1899*a*, pp. 38, 42. Dorsal arm-plates largely in contact. Arm-spines nearly smooth, the rows widely separated dorsally.

O. Nuttingii Ver. Arm-spines four, short, tapered. Disk-scales small, exposed, bearing small spinules. Radial shields partly exposed, narrow, separated. Tentacle-scales single, large.

nn.—*Ophiomitrella* Ver., 1899*a*, pp. 39, 43. Dorsal arm-plates separated by the side-plates. Arm-spines slender, thorny; the basal rows approximate dorsally.

O. lævipellis (Lym.) Disk-scales small, sometimes entirely naked, sometimes with small scattered granules. Radial shields small, separate, partly naked. Tentacle-scale single, small, acute. A pair of papillæ on the first under arm-plate.

mm.—Disk-scales mostly concealed, but radial shields naked.

o.—*Ophiacanthella* Ver., 1899*a*, p. 39. Basal rows of spines not approximate dorsally. Dorsal arm-plates largely in contact. Radial shields long, mostly naked, in contact by their edges. Arm-spines nearly smooth. Three tooth-papillæ. Oral papillæ four, conical, all similar.

O. Troscheli (Lym.) Arm-spines six, tapered. Disk-scales concealed, bearing granules and scattered spines. Tentacle-scale single, lanceolate.

oo.— *Ophioscalus* Ver., 1899*a*, pp. 39, 42. Dorsal arm-plates separated. Basal rows of spines closely approximate dorsally. Radial shields large, broad, naked, in contact for their whole length. Two or three tooth-papillæ. Arm-spines thorny and glassy.

O. echinulata Lym. Disk-scales small, nearly concealed by numerous slender, thorny spines.

AA.—The oral shield is separated from the side arm-plates by the distal lobe of the elongated adoral shields, which are therefore, not entirely proximal to the oral shields.

D.—Adoral shields narrow, trilobed, the narrow distal lobe separating the oral shield from the side arm-plate. Disk-scales usually concealed by cuticle and spinules.

E.— *Ophiopora* Ver., 1899*a*, p. 43. No tentacle-scales, the pores are very large; spines small, usually smooth.

O. Bartletti (Lym.) Ver. One spiniform distal oral papilla by the side of the oral tentacle-pore. Disk covered with acute spinules.

EE.—One or two tentacle-scales.

p.— *Ophiolimna* Verrill, 1899*a*. Arm-spines seven or eight, nearly smooth, placed obliquely on the distal part of the plates, not strongly divaricate. Jaws more or less granulated. Disk-scales and radial shields concealed, bearing granules and spines.

**O. Bairdii* (Lym.) Ver. Upper arm-plates separated. Rows of spines approximate dorsally. Tentacle-scale single.

O. mixta (Lym.) Ver. Upper arm-plates joined. Rows of spines wide apart dorsally. Two flat tentacle-scales.

pp.— *Ophiopristis* Ver., 1899*a*. Arm-spines serrulate, not obliquely placed. Strongly divaricate. Dorsal arm-plates separated. Tooth-papillæ usually three.

q.—Spines partly flattened, serrulate on the edges. A row or cluster of several distal oral papillæ at the large oral tentacle-pore. Two tentacle-scales on the basal joints.

O. hirsuta (Lym.) Ver. Disk-spines slender, tapered, acute. Arm-spines five or six, strongly serrate on the edges. Three tooth-papillæ. Two flat tentacle-scales.

O. ensifera Ver. Disk-scales visible, bearing small conical spinules. Spines four, blunt, mostly flat. Two flat tentacle-scales on the basal joints.

O. cervicornis (Lym.) Ver. Disk with granules and small acute spinules. Tentacle-scales two, spiniform; pores very large, open. Arm-spines six, short, flat, serrate.

qq.—*Ophiotreta* Ver., 1899*a*, p. 40. Only one or two, rarely three, oral tentacle papillæ, which are flat. Two to four or more tooth-papillæ. Arm-spines terete or only a little flattened, slender, serrulate or nearly smooth.

O. lineolata (Lym.) Ver. Arm-spines six or seven, slender, nearly smooth. Tooth-papillæ three to five. Two unequal tentacle-scales on several basal joints. Disk evenly granulated, and with a few scattered spines. Jaws often bear granules.

O. sertata (Lym.) Ver. Tooth-papillæ two or three. Spines seven, finely serrulate, partly flattened.

DD.—*Ophiothamnus* Lym. Adoral shields large, wedge-shaped with the broad distal end separating the narrow ovate oral shield from the side arm-plate. Disk-scales exposed. Radial shields more or less naked, close together.

**O. gracilis* Ver. Arm-spines four or five, upper ones slender, lowest rough. Disk with truncate, thorny stumps. Tentacle-scale spiniform or palmate.

O. vicarius Lym. Disk-scales bear slender, tapered, acute spinules. Tentacle-scale small, conical.

O. exigua (Lym.)

Ophiacantha should be restricted and subdivided.

In this group the armature of the disk does not seem to be correlated with other important characters; neither does the number nor the length of the arm-spines, nor their solidity, or translucency, or hollowness, nor their degrees of roughness.

One of the characters that seems to be of much importance for the separation of the typical genus, from other allied generic groups,

hitherto confounded with it, is the nature of the adoral shields. In the typical group these are small and quite in front of the oral shields. In several other divisions they extend outward in a distal lobe that separates the oral shield from the side arm-plates, as in *Ophiocopa*, etc. (See group AA, p. 327, and group XIII, p. 340.)

Other characters of importance for the separation of groups of some value, are the presence of several tooth-papillæ at the apex of the jaw (groups B, C, G, K, pp. 330–333); the presence of a large submarginal oral tentacle-pore, with special papillæ around it, in a row or cluster (see group J, p. 333); the partial nakedness of the disk-scales and radial shields (group F, p. 332); the size and contiguity of the radial shields (group G, p. 332); the contiguity of the dorsal arm-plates (group G, p. 332); absence of tentacle-scales and the large size of part or all of the pores (group H, p. 333, and group E, p. 332).

Some of these characters, even those of most importance, have not been referred to in many of the published descriptions, nor represented in the figures. Therefore many of the species cannot, at present, be definitely classified. Mr. Lyman's figures, in the Voyage of the Challenger, are generally very accurate, but even some of these fail to show certain details of structure needful for accurate classification of the species of this genus.

Ophiomitra Lyman (typical group) differs but little from some sections of *Ophiacantha*. It has the tooth-papillæ and distal oral papillæ numerous and clustered, as in section C; the distal oral tentacle-pore is large and partly exposed, as in section J. The radial shields are large and nearly naked and the disk scales are visible and spinose. Several species referred to *Ophiacantha* by Lyman also have naked disk-scales and radial shields (groups F and B, *aa*).

Subdivisions of Ophiacantha.

From the preceding remarks and table, it will be plain that several genera and subgenera* may be separated from the old genus *Ophiacantha* with characters that appear to be of as great morphological value as those that characterize, for instance, *Ophiomitra* or *Ophiochiton*.

* Most of these subdivisions were proposed in the Report on the Ophiuroidea of the Bahama Exped., Nat. Hist. Bull., Univ. Iowa, v, 1899. (Designated as 1899*a* in this article.)

Series I.

Ophiacantha (restricted). Types, *O. setosa* and *O. bidentata.*

Group A.—Typical *Ophiacantha.*

Oral papillæ form a simple row. One median tooth-papilla at the tip of the jaw. No special oral tentacle-scales at the distal angles of the mouth-slits, though the outer papilla, which serves as a tentacle-scale, may be wider than the rest. Oral tentacle-pore not exposed outside of the jaw-margin. Disk-scales more or less obscured by integument and bearing spinules, thorny stumps, crotchets, or granules. Radial shields rather narrow, separated more or less, mostly concealed by cuticle. Arm-spines usually long and slender, unequal, more or less rough, often glassy or translucent, often hollow. Dorsal arm-plates usually all separated by the side arm-plates; sometimes, on a few basal joints, they are slightly in contact.

To this section a large majority of all the described species belong.

Group B.—*Ophientodia* Ver., 1899*a*, p. 41.

Two, three or four tooth-papillæ clustered at the tip of the jaws. Otherwise nearly as in section A. Distal oral papillæ not clustered.

The published figures of several species shows two paired papillæ, directed centrally, at the tip of the jaws. They may not always stand on the dental plate and in such cases should be counted as oral papillæ, but in some cases they have been determined as true tooth-papillæ. Probably in this section there may be a central tooth-papilla that has been overlooked in some species, by reason of its position, high up on the jaw, or its smaller size. In some cases it may have been accidentally lost. But in some specimens either two or three papillæ occur on different jaws. Therefore, I consider the presence of *three* tooth-papillæ as the usual character of this division. The species need revision as to the tooth-papillæ. (See also group VII, page 338.)

a.—Radial shields rather small, narrow, mostly concealed.

O. scutata Lym. Three tooth-papillæ; eight to ten thorny arm-spines. Radial shields long and narrow, sometimes naked.

O. cuspidata Lym. Three tooth-papillæ.

O. pectinula Ver. Three or four tooth-papillæ. Dorsal arm-plates pectinate on the outer edge.

aa.—*Ophioscalus* Ver., 1899*a*, p. 42. Radial shields large, wide, closely joined, naked. Disk-scales covered with rough spinules. Arm-spines approximate dorsally.

O. echinulatus Lym. Arm-spines ten, very thorny and glassy. Tentacle-scales spiniform, two on the first joint. Two or three tooth-papillæ.

Group C.—*Ophiectodia* Ver., 1899*a*, p. 42.

Outer oral papillæ (oral tentacle-scales) several, forming a cluster or a double row, some often standing on the lower face of the jaw or adoral shield. Tooth-papillæ one to three, or more. The oral papillæ are clustered nearly as in typical *Ophiomitra*.

O. enopla Ver. Tooth-papillæ, one or two.

O. rosea Lym. Tooth-papillæ clustered, three or more.

O. spectabilis Sars. Tooth-papillæ three or four, in a cluster.

Series II.

Group D.—*Ophialcæa* Ver., 1899*a*, pp. 38, 42. Types, *O. Nuttingii* (Ver.) and *O. tuberculosa* (Lym.). (See p. 326.)

The dorsal arm-plates are broadly in contact, at least on many of the proximal joints. Disk-scales bear spinules or granules. Radial shields separate, sometimes more or less exposed distally, sometimes covered. Arm-spines rather short, few, nearly smooth, the rows not approximate dorsally. Oral papillæ nearly as in typical *Ophiacantha* (group A).

O. Nuttingii Ver., 1899*a*, p. 46. Arm-spines four, short. Oral-shield very large, ovate. Disk-scales more or less exposed, bearing conical spinules.

O. rufescens Kœhl. Off the Azores, 845 meters. Ventral plates contiguous. Arm-spines six, finely serrulate. Two large elongated tentacle-scales. Oral papillæ six or seven, outer one largest. Disk-scales covered with fine roundish granules. Distal end of radial shields naked.

O. tuberculosa Lym., '98. E. Indies. Disk and radial shields covered with cuticle and granules. Arm-spines four. One tooth-papilla. Three oral papillæ, the distal one broad and notched. Oral shield not large, transverse. Tentacle-scale single, small.

Group E.— *Ophientrema*, sub-gen. nov. Type, *O. scolopendrica* (Lym.).

Tentacle-pores and scales on one, or a few, basal joints and larger than usual,* farther out decreasing rapidly to a small or rudimentary size. Disk-scales concealed by granules. Radial shields sometimes partly exposed. Spines numerous, nearly smooth. Mouth-parts as in typical *Ophiacantha.*

O. granulosa (Lym.). Radial shields largely exposed, broad, in contact distally. Arm-spines ten, slender, the rows nearly approximate dorsally. Tentacle-pores of the first joint large, with one flat scale; of others small, with a narrow scale. Dorsal arm-plates all separate. Pacific.

O. scolopendrica (Lym. '83). Radial shields nearly concealed, close together. Arm-spines seven, unequal, the rows not approximate dorsally. Tentacle-pores large on four joints, with a small scale, rudimentary or lacking distally. Dorsal arm-plates joined on a few basal joints. European.

Group F.— *Ophiomitrella* Ver., 1899*a*, p. 39. Type, *O. lævipellis* (Lym.).

Disk-scales visible, bearing granules or spinules. Radial shields partly naked, not large, wide apart. Arm-spines slender, thorny or serrulate; the rows approximate dorsally in the type. One tooth-papilla. In the type-species a pair of special, distal, oral tentacle-papillæ, on the first under arm-plate,† directed into the mouth-slit. Adoral shields wide. Otherwise the mouth parts are nearly as in typical *Ophiacantha.*

O. lævipellis (Lym., '83). Arm-spines eight, slender, thorny. Disk-scales naked or partly granulated. Upper arm-plates separated.

Group G.— *Ophiacanthella* Ver., 1899*a*, p. 39. Type, *O. Troscheli* (Lym.).

Radial shields naked, long, parallel, in contact by their edges. Dorsal arm-plates largely joined. Three tooth-papillæ. Arm-spines nearly smooth.

* Several species that have been referred to *Ophiomitra* also have this character. (See *Ophiomitra*, section AA, p. 351.)

† The two papilliform appendages of the first under arm-plate are here supposed to be movable, but with the published figures and descriptions it is not always possible to distinguish them from the solid, immovable, crest-like lobes which are present on these plates in the same position in many species, including *O. bidentata.* Among extralimital species, these papillæ are found in some species, such as *O. serrata* Lym., that have the disk-scales and radial shields concealed.

Series III.

In the following groups the oral shield is separated from the side arm-plates by the adoral shields.

Group H.—*Ophiopora* Ver., 1899*a*. Type, *O. Bartletti* (Lym.).

Tentacle-pores all large and open. No tentacle-scales.

Group I.—*Ophiolimna* Ver., 1899*a*. Type, *O. Bairdii* (Lym.).

Spine-crest of the side arm-plates distally situated and oblique. Spines nearly smooth.

Disk granulose and spinulose. Jaws more or less granulose.

Group J.—*Ophiopristis* Ver., 1899*a*. Type, *O. hirsuta* (Lym.).

A row of distal oral papillæ alongside of the large outer ora tentacle-pore. Arm-spines partly flattened with serrulate edges. (See p. 347.)

Group K.—*Ophiotreta* Ver., 1899*a*, p. 40. Type, *O. lineolata* (Lym.).

One or two flat, distal oral papillæ by the side of the large oral tentacle-pore. Two or three tooth-papilla. Spines mostly terete, but sometimes flattened and with serrulate edges. (See p. 328.)

Group L.—*Amphipsila* Ver., 1899*a*, p. 55. Type, *A. maculata* Ver.

Oral papillæ form a simple row. Two or three tooth-papillæ in the marginal series. Disk-scales and radial shields naked, small. Tentacle-scale slender, spiniform or palmate. Arm-spines serrulate, flattened, hollow. (See p. 348.)

Ophiocopa Lym. also belongs in this series.

Ophiacantha, sens. ext.

Artificial groups of species from the West Indian region and from the East Coast of North America, arranged according to various special characters.

All the species appear in groups I and II. In these two groups all the northern species are indicated by an asterisk prefixed. These groups are not intended as natural sections of the genus, though they

may be so in some cases, but merely as aides for the comparison of the species. They may be considered as morphological tables. The genus in these XIII groups is taken as in Mr. Lyman's works.

For the natural subdivisions, see pages 329–333.

I.

Arm-spines long, thorny or prickly, more or less glassy.

a.—Rows of spines approximate dorsally on first or second joint beyond disk.

b.—Radial shields covered ; disk spinulose.

O. aspera Lym., '78. Arm-spines ten, slender, very thorny.

O. pentacrinus Lütk. Spines nine or ten, long, very slender, slightly thorny.

O. pectinula Ver., sp. nov. Spines ten or eleven, very slender and glassy. Tooth-papillæ two to four. A cluster of oral tentacle-papillæ.

**O. millespina* Ver., '79. Spines ten. Disk spinules slender, with three or four long sharp branches.

**O. gracilis* Ver.,† '85. Spines four to six, short, except the upper basals; lower ones thorny. Disk-scales naked, with hour-glass shaped, thorny stumps.

**O. varispina* Ver., '85. Spines eight, little rough, glassy.

bb.—Radial shields largely exposed.

O. lævipellis Lym., '83. Spines seven or eight, little flat; naked disk-scales.

O. echinulata Lym., '78. Spines nine or ten, long ; disk spinose. See under *Ophiomitra.*

aa.—Basal rows of spines not closely approximated dorsally.

O. stellata Lym., '75. Arm-spines seven, very thorny.

O. scutata Lym., '78. Spines nine or ten, slightly thorny.

**O. granulifera* Ver., '85. Spines eight or nine, part of them slightly thorny.

II.

Arm-spines, in the adult, not distinctly thorny, but often finely serrulate on the edges, especially the lower ones ; mostly rather opaque, but often translucent in alcohol ; usually hollow.

†This singular species, on reexamination, proves to belong to *Ophiothamnus.* Its long, wedge-shaped oral shields are widely separated from the arm-plates by the broad adoral shields.

a.—Spines slender, tapered, terete, or but little flattened; often nearly smooth, or only microscopically serrulate; rougher when young.

b.—Basal rows of spines approximate dorsally on the first or second joint.

c.—One odd tooth-papilla.

O. vepratica Lym. Arm-spines eight, long and tapered.

O. segesta Lym., '78. Disk-spines slender, mixed with thorny stumps.

**O. Bairdii* Lym., '83. Disk with granules and some tapered spines. Jaws granulated more or less.

**O. bidentata* (Retz.). Spines somewhat rough or serrulate, especially when young. Disk-spinules are small, thick, rough, obtuse stumps.

**O. abyssicola* Sars. Disk-spinules minute.

**O. aculeata* Ver., '85. Spines eight or nine, tapered, upper ones nearly smooth. Disk-spinules with three to five sharp points.

**O. anomala* Sars.† Spines eight or nine, all terete, tapered, finely serrulate; six arms.

**O. enopla* Ver., '85. Spines four or five, serrulate; outer oral papillæ clustered.

cc.—Two or three tooth-papillæ. Distal oral papillæ or oral tentacle-scales clustered.

**O. spectabilis* Sars. Disk-spinules large, tapered, acute.

bb.—Basal rows of spines not very closely approximate dorsally.

d.—Dorsal arm-plates, at base of arms, separated by side plates, or only slightly in contact.

**O. fraterna* Ver., '85. Disk covered with minute spinules having three to five sharp points.

**O. crassidens* Ver., '85. Disk with small tapered spines. Oral papillæ very stout.

O. Bartletti Lym., '83. (*Ophiopora* Ver., p. 345.) No tentacle-scales.

dd.—Dorsal arm-plates, at base of arms, distinctly joined.

e.—Disk and radial shields covered with spinules, or mixed spines and granules.

† This species is viviparous. One specimen from off Nova Scotia has several six-armed young clinging about the mouth and genital slits.

O. cosmica Lym., '78. Arm-plates only a little joined.

O. lineolata Lym., '83. Arm-plates broadly joined. Disk with grains and some spines.

ee.—Jaws also more or less granulated.

O. mixta (Lym., '78). Disk with grains and spines. (*Ophiolimna* V., p. 345.)

eee.—Disk granulated; radial shields partly naked.

f.—Radial shields joined. (*Ophiacanthella* V., p. 344.)

O. Troscheli Lym., '78.

ff.—Radial shields separated. (*Ophialcœa* V., p. 331.)

O. Nuttingii Ver., 1899*a*, p. 46.

aa.—Spines partly distinctly flattened and serrulate on the edges; the rows not approximate dorsally on the basal joints. Two or three tooth-papillæ. (*Ophiopristis* V., p. 347.)

O. hirsuta Lym., '75. Spines four or five, slender, part flat. Disk with long, very slender spines.

O. ensifera Ver., 1899*a*, p. 47. Spines four, stout, mostly flat. Disk with small, conical spinules.

O. cervicornis Lym., '83. Spines five, mostly slender, acute.

O. sertata Lym. Spines seven, translucent. Tentacle-scales two.

III.

Radial shields more or less exposed.

A.—Radial shields partly or wholly in contact.

a.—Radial shields rather wide, angular.

O. echinulata. Inner edges of radial shields wholly in contact. (See *Ophioscalus*, p. 331, also p. 342.)

aa.—Radial shields narrow and long.

O. Troscheli. Shields naked and largely in contact. (See *Ophiacanthella*, pp. 332, 344.)

AA.—Radial shields separated, not large.

b.—Never entirely concealed.

O. lœvipellis. Small, wide apart. (See *Ophiomitrella*, pp. 343, 352.)

bb.—Sometimes nearly or quite concealed.

O. sertata. Small, pear-seed-shaped.

O. scutata. Long and narrow.

O. ensifera. Small, narrow, usually largely covered. (See *Ophiopristis*, p. 347.)

O. Nuttingii. Crescent-shaped, narrow. (See *Ophialcæa*, p. 331.)

Several other species are apt to have the distal end of the radial shields more or less exposed. In many cases the covering is probably accidentally rubbed off.

IV.

Dorsal arm-plates, on basal part of arms, in contact, not separated by the side-plates.

a.—Dorsal arm-plates rather narrow.

O. lineolata. Ventral plates slightly separated. (See *Ophiotreta*, pp. 333, 347.)

aa.—Dorsal arm-plates broad.

b.—Dorsal plates extensively joined. (See *Ophiacanthella*, p. 344.)

O. Nuttingii. Ventral plates in contact.

O. Troscheli. Ventral plates separated.

bb.—Dorsal plates little joined.

O. cosmica. Ventral plates separated.

O. mixta. (See p. 346.)

V.

Tentacle-pores all unusually large.

O. Bartletti. No tentacle-scales. (See *Ophiopora*, p. 345.)

O. cervicornis. Two spiniform tentacle-scales. (See *Ophiopristis*, pp. 333, 347.)

VI.

A cluster of three or more tooth-papillæ at the tip of the jaw.*

O. lineolata (three or four tooth-papillæ).

O. scutata (three or four, often only two visible below).

* Several extralimital species belong to this group, such as *O. Valenciennesi* Lym., with three tooth-papillæ and one oral tentacle-scale; *O. cuspidata* Lym.; *O. marsupialis* Lym.; *O. rosea* Lym.; the last has a cluster of tooth-papillæ and also several oral scales. (See p. 338, note, and p. 348.)

O. sertata (three, only two visible below).

O. Troscheli (three tooth-papillæ).

O. spectabilis (three to five tooth-papillæ; a cluster of distal oral papillæ.

O. pectinula Ver. (two or three tooth papillæ; three or more distal oral tentacle-papillæ).

VII.

A pair of tooth-papillæ (or apparent tooth-papillæ) close together, at the tip of the jaw; no odd median one visible from below. (In some species the odd papilla may be concealed by the pair below it, when it is actually present, but published figures and descriptions are not definite enough to determine this in many cases; in some cases it may have been accidentally broken from the type-specimen. It certainly seems to be the normal condition, in group *a*, to have only two.)

a.—A distal cluster or row of special oral tentacle-scales. See *Ophiopristis*, p. 347.

O. cervicornis.

O. ensifera.

O. hirsuta.

aa.—Only one or two distal oral tentacle-scales.

O. Bartletti. No tentacle-scale on arms.

O. echinulata. Two spiniform tentacle-scales on arms.

VIII.

A cluster of oral papillæ or oral scales near the outer corner of the mouth-slits, at the outer oral tentacle-pore, or else one or two special oral scales by the side of the tentacle-pore, which is on, or nearly outside of, the margin of the mouth-slit. (Published figures are often inaccurate as to this character.)†

a.—Several distal oral tentacle-scales or papillæ to each pore.

O. cervicornis. About four spiniform distal papillæ in a row.

O. pectinula Ver. Three to four distal papillæ.

**O. enopla.* Four to six distal papillæ in a cluster.

† Several extralimital species belong to this group; among them are: *O. rosea* Lym. (in subsection *a*); *O. marsupialis* Lym.; and *O. Valenciennesi* Lym. (in *aa*.)

O. hirsuta. Two to four papillæ in a row.
O. ensifera. Four to five papillæ in a curved irregular row.
* *O. spectabilis.* Three or four in an irregular group.

aa.—One or two special distal oral scales or papillæ, usually attached to the adoral plate ; oral tentacle-pore large.

O. Bartletti. One, spiniform, distal oral papilla.
O. lineolata. Two flat papillæ.
O. sertata. Two flat papillæ.
O. lævipellis. One flat papilla, attached to first arm-plate.

IX.

A pair of small, apparently movable, oral papillæ attached to the proximal end of the first under arm-plate, which is emarginate.† In most species of the genus there are, in this place, two flat, usually fixed, processes or crests. It is generally impossible to tell, from published figures, the character of these parts. They are generally badly represented.

* *O. anomala.*
O. lævipellis. (See group VIII, *aa.*)

X.

Oral papillæ unusually large and stout.

* *O. crassidens.* Three or four thick and rough papillæ, the distal ones smaller.
* *O. varispina.* Three or four broad, flat, obtuse papillæ.

XI.

Tentacle-scales of peculiar or unusual forms, or spiniform.

a.—Tentacle-scales elongated ; flat, spatulate, or lobate distally.

O. aspera. End of tentacle-scale branched or thorny.
* *O. varispina.* End spatulate.

aa.—Tentacle-scales elongated, slender or spiniform.

O. echinulata. Scales dagger-shaped ; two pairs on first joint.
O. cervicornis. Two, spiniform, slender.
O. Troscheli. One, long, acute.

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† Of extralimital species, *O. serrata* Lym., *O. cornuta* Lym., and *O. Valenciennesi* Lym. belong to this group.

O. vepratica. One, large, conical.
O. segesta. One, small, acute.
* *O. gracilis.* One, slender, palmate, distal ones acute.
O. pectinula V. Spiniform, two or three on first joint.

XII.

Tentacle-scales wanting. Adoral shield as in XIII. (*Ophiopora* V.)
O. Bartletti (see p. 345). Outer oral tentacle-pore large, with a conical papilla.

XIII.

Adoral shields long, usually trilobed; the distal lobe separates the oral shield from the side arm-plate. In all typical species of the genus the oral shield and adoral shield both join the side arm-plate.

A.—One or two tentacle-scales.
B.—Disk-scales mostly concealed.

a.—Jaws not granulated, or only slightly so. (*Ophiopristis* V.)
b.—A row or series of special distal oral papillæ.

O. hirsuta. (See p. 336.)
O. ensifera. (See p. 336.)
O. cervicornis. (See p. 347.)

bb.—One or two distal oral papillæ or scales. (*Ophiotreta* V.)†
O. sertata. (See p. 348.)
O. lineolata. (See p. 348.)

AA.—Jaws granulated. (*Ophiolimna* V.)

* *O. Bairdii.* (See p. 346.)
O. mixta (Lym., as *Ophiochæta*). See p. 346.

BB.—Disk-scales entirely exposed. Radial shields more or less naked. Adoral shields broad distally. (*Ophiothamnus.*)

* *O. gracilis* Ver. Disk-scales bear hour-glass-shaped spinules with a terminal group of points.

AA.—No tentacle-scales. Tentacle-pores all very large and open. (*Ophiopora* V.)

O. Bartletti. (See p. 345.)

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† Among extralimital species that belong to this group, are *O. placentigera* (Lym.) and *O. Valenciennesi* (Lym.).

Ophiacantha scutata Lyman.

Ophiacantha scutata Lym., Bull. Mus. Comp. Zool., vol. v, p. 229, pl. i, figs. 1–3, 1878; op. cit., vol. x, p. 261, 1883 (variations).

Specimens sent to me by Mr. Lyman differ somewhat from his figures and descriptions.

The oral papillæ may be either three or four on different jaws of the same specimen; they are rather stout, spiniform, the inner largest, and all appear to be on the buccal plate, but the jaw-plates and adoral shields are so closely united together that the sutures are mostly invisible. There is often an extra outer papilla of small size, which is situated at the union of the buccal and adoral plates, outside the oral tentacle-pore, which is large, but situated inside the mouth-slit. Tooth-papillæ may be from two to four on different jaws of a large specimen. Usually there is a stout median one with a pair of smaller ones just above it, invisible from below, and another small median one outside. The last is often lacking, and the upper pair may be replaced by a single one, which is, perhaps, absent in small specimens. The oral shield is more nearly transverse-elliptical than figured, with a more obtuse inner angle. The madreporic shield is longer than the others and more rhombic, thickened, with a median concavity. The adoral shields of a large specimen are smaller than figured, narrow and tapered proximally, and the ends do not meet medially, but in small specimens they are nearly as figured and meet medially. The first under arm-plate is small, rounded, emarginate on the inside, with a small vertical crest at each side, directed inward.

The under arm-plates of the larger specimen are unlike the figure; they are narrower and longer, with the distal end projecting and strongly convex; the proximal end is very obtusely angulated or subtruncate; a little farther out on the arm they become more oblong, with the outer end more projecting and the inner end truncate and scarcely narrowed. They are slightly separated.

Tentacle-scales, on two or three of the basal joints, are flat, erect, lanceolate, and cuspidate; occasionally, in the larger examples, there are two on the first joint. Beyond the fifth or sixth joint they become slender, acute, spiniform. The first two or three pairs of tentacles are decidedly larger than those beyond.

Arm-spines, in the largest rows, are ten, shaped about as figured, with numerous small, sharp prickles on all sides. The basal rows

approximate dorsally, but not so closely as in some other species. Upper arm-plates nearly as figured, transverse lozenge-shape, with the distal edge convexly curved at first, but becoming prominent and angulated farther out.

The whole upper surface of the disk, including the radial shields, is thickly covered with small, short, thorny spinules or stumps, terminated by three to five or more short, sharp points. Diameter of disk of largest specimen, 14^{mm}; of smallest, 7^{mm}.

Off Barbadoes, 200 fathoms, Blake Exped.

Ophiacantha (Ophiectodia) pectinula, sp. nov.

Disk-scales small, entirely hidden by cuticle and bearing crowded, very slender, elongated spinules, thorny on the sides and at the tip. Radial shields small, near together, entirely hidden by cuticle and spinules.

Two to four clustered tooth-papillæ. Oral papillæ numerous, nearly equal, compressed, spiniform, smaller than the tooth-papillæ; four or five form a regular lateral row; five or six more distal ones form a cluster or two rows, and serve as oral tentacle-scales. Oral shield broadly pelecoidal, wider than long, with a slightly convex distal lobe. Adoral shields about as large as the oral, oblong-lunate, meeting within.

Tentacle-scales long, acute, spiniform, thorny, two at the basal pores. Arm-spines long, very slender, thorny, very acute; some of the rows nearly approximate dorsally at base of arms, where there are nine or ten in a row. Dorsal arm-plates small, quadrant-shape, the sides nearly straight, the outer end convex with a marginal row of minute, sharp denticles. Under arm-plates small, widely separated; the inner end forms an obtuse angle; the outer end is convex, prominent, side arm-plates prominent, meeting above and below.

Diameter of disk, 8^{mm}; length of arms, broken at tips, about 40^{mm}.

West Indies, Blake Exped., 1883.

This was sent to me by Mr. Lyman as *O. echinulata*, with which it does not agree. The type of the latter has broad naked radial shields, in close contact, and the oral papillæ are much fewer and are figured as forming a simple row. The spines and tentacle-scales are similar, though the basal rows of spines approximate more closely dorsally.

Ophiomitrella Ver., 1899*a*, p. 39. (See p. 336, and p. 352.)

Ophiomitrella lævipellis (Lym.) Ver.

Ophiacantha lævipellis Lym., Bull. Mus. Comp. Zool., vol. x, p. 259, pl. vi, figs. 82–84, 1883.

Ophiomitrella lævipellis Verrill, Ophiur. Bahama Exped., v, p. 39, 1899.

About twenty specimens of this species were sent to me by Mr. Lyman. They show considerable variation among themselves, and all differ more or less from his figures and description.

The disk is strongly five-lobed, owing to a deep incurvature of the interradial areas. The upper side is closely covered with small thin scales, which are usually smooth and nearly destitute of granules, but in some examples there are a few scattered, low, verruciform grains, especially near the margins; in others the grains are thinly scattered over nearly all the surface; in some cases part of the grains are conical. The scales themselves vary somewhat in size and distinctness.

The radial shields appear to be long and narrow and nearly parallel; a narrow ridge, in dry specimens, often runs inward nearly to the center from each shield; only the ends of the shields are commonly exposed; this naked part varies in form and extent, but is usually long, narrow, wedge-shaped, widest distally, and the ends often project somewhat beyond the edge of the disk over the base of the arm and may bear a few marginal granules. The ends of the shields are sometimes near together, being separated by a space less than half their breadth; in other specimens they are separated more than their breadth.

Oral papillæ vary in number, even on the different jaws of the same specimen, from three to five; most frequently there are three in the regular series, with a smaller and much shorter distal one, just at the distal end of the adoral shield and above the large pore of the outer oral tentacle. In many cases this outer papilla develops to full size, like the next one, which is stout, erect, obtuse, larger than those that follow it; the latter are usually compressed vertically, subacute; the inner one is a little longer and more conical. Attached to each inner corner of the first arm-plate there is a small vertically flattened scale or papilla that appears to be movable; it guards the oral tentacle on the inside and is sometimes wanting. It corresponds to a similar process which in several other species seems immovable.

Tooth-papilla one, or perhaps none, for the odd papilla at the tip of the jaw agrees nearly in size and form with the true teeth. It

varies in form, however, even on the different jaws of the same specimen. It is usually ovoid, or obtusely lanceolate, or even obovate; sometimes it is acute or mucronate at tip, and then it differs a little more decidedly from the teeth. It stands on the tip of the dental plate.

The oral and adoral shields are thickened and prominent, shaped nearly as in the figure by Mr. Lyman. The oral shield is small and somewhat fan-shaped, or rather pelecoidal, for the inner lateral edges are strongly incurved. In one specimen the oral shields were unusually narrow and acutely angled proximally. The adoral shields are relatively large, lunate, confined to the proximal side of the oral shield.

First under arm-plate is small, irregularly six-sided, strongly emarginate within. The second is much broader than long, curved distally, and obtusely angled proximally. Those following are still shorter, transversely narrow-elliptical, with a very obtuse proximal angle, or nearly truncate and broadly curved distally, often showing a slight median incurvature of the edge, which becomes more distinct on those farther out. They are thick and widely separated by the side arm-plates, which lie in grooves. More distally they become more nearly square, with the inner end more angulated.

Tentacle-scale small, spiniform, subacute, rather rough, becoming more slender farther out. All the tentacle-pores are small.

Arm-spines about as figured, except that many of them are more thorny, especially those near the base of the arms and in the upper series, most of which have irregular sharp divergent thorns; farther out they are mostly minutely serrulate. They are not usually distinctly flattened, as stated, but slender, terete, tapered, acute. The rows are closely approximate dorsally on the second and third joints, becoming separated farther out.

Upper arm-plates thick, swollen, widely separated, rather triangular or quadrant-shaped, with an obtuse proximal angle and a broadly convex distal edge. On the middle of the proximal part there is a small, wart-like elevation.

Diameter of disk of those described above, 3 to 6^{mm}.

Off St. Vincent, 88 and 124 fathoms. Blake Exped.

Ophiacanthella Verrill, 1899*a*, p. 39. Type, *O. Troscheli* (Lym.) Ver.

Three terminal tooth-papillæ in a group. Radial shields long, narrow, largely in contact, more or less naked. Disk-scales obscured by cuticle, granulose or spinulose. No special oral tentacle-scales.

Oral papillæ all similar. Dorsal arm-plates largely in contact. Tentacle-scales one or two, all similar. Spines slender, finely serrulate or nearly smooth.

This genus is, in most respects, closely related to *Ophiomitra*. It differs in having the disk-scales mostly concealed by cuticle; in having three apical tooth-papillæ, instead of one; in having the dorsal arm-plates joined; and in the smoothness of the spines.

It is separated from *Ophiacantha* especially by the naked and contiguous radial shields, and from the typical section of that genus by having three tooth-papillæ and contiguous dorsal arm-plates.

Ophiopora Ver., 1899*a*, pp. 39, 43. Type, *O. Bartletti* (Lym.) Ver.

Adoral plates with two distal lobes, one of which embraces the lateral edge of the oral shield and separates it from the side arm-plates, as in *Ophiopristis*. No tentacle-scales; tentacle-pores all very large and widely open. Two or three tooth-papillæ. Outer oral tentacle-pore is submarginal and furnished with one special, acute, papilla or oral tentacle-scale on the adoral shield. Disk-scales, above, and the radial shields are concealed by cuticle and spinules; on the under side the scales are visible. Arm-spines few, nearly smooth. Dorsal arm-plates are separated by side plates.

This genus is closely allied to *Ophiolimna*, but differs in the large open tentacle-pores, without scales.

Ophiopora Bartletti (Lym.) Ver.

Ophiacantha Bartletti Lym., Bulletin Mus. Comp. Zoöl., vol. x, p. 256, pl. v, figs. 73–75, 1883.
Ophiopora Bartletti Ver., Ophiur. Bahama Exp., Bull., v, p. 39, 1899.

This is the only known species of this group. The disk is covered by slender acute spinules. The four arm-spines are small, tapered, rather short, nearly smooth. The side arm-plates are not prominent.

West Indies, 291 fathoms, Blake Exped.

Ophiolimna Ver., 1899*a*, pp. 40, 44. Type *O. Bairdii* (Lym.) Ver.

Adoral shields trilobed; one distal lobe extends back between the oral shield and first side arm-plate, so that the oral shield is detached from the arm. The jaws may bear more or less granules. Disk-scales and radial shields covered with granules, or spinules, or both.

Side arm-plates prominent, with the oblique, spine-bearing crest near the distal margin, so that the spines are directed more or less distally, especially on the distal half of the arm. One or two tooth-papillæ. Several simple oral papillæ in a regular row, the outer ones broader. One or two tentacle-scales. Arm-spines tapered, nearly smooth, rather short.

This genus agrees with *Ophiacantha* and *Ophiomitra* in its mouth-parts, but differs from both in the more oblique position of the rows of arm-spines and in the separation of the oral shields from the side arm-plates. In the last character it agrees with *Ophiopristis*, *Ophiopora*, etc.

The type, *O. Bairdii* (Lym., 1883,)* was taken by the Blake, off the east coast of the United States, in 1242 and 1394 fathoms, and by the United States Fish Commission Steamer Albatross in 1390 fathoms, in the same region.

This species has seven or eight smooth, acute spines, of moderate length ; the rows closely approximate dorsally ; the disk bears small acute granules and a few short spines ; jaws partly naked, but with some granules; outer oral papilla (oral tentacle-scale) broad and flat; one tooth-papilla ; one small tentacle-scale ; oral shield broadly obovate; dorsal arm-plates scarcely joined on basal joints. The spine-crests are distally placed on the side arm-plates, and the spines are mostly directed distally, or often lie nearly parallel to the arms.

Ophiolimna mixta (Lym.) Verrill.

Ophiochœta ? mixta Lyman, Bulletin Mus. Comp. Zool., vol. v, p. 222, pl. ii, figs. 40–42, 1878; Voyage Challenger, Oph., vol. v, p. 110, pl. xxxix, figs. 15–17, anatomy, 1882.

Ophiolimna mixta Ver., Ophiur. Bahama Exped., Bull., v, p. 40, 1899.

This species has two large flat tentacle-scales; seven smooth arm-spines ; two tooth-papillæ; six oral papillæ; jaws granulated ; dorsal and ventral arm-plates not separated by the side arm-plates on the basal joints ; disk crowdedly covered with granules mixed with some slender spines.

The internal structure, as figured by Lyman, is much like that of *Ophiacantha*. The radial shields, seen from within, are broad, three-cornered, separated. It does not appear to be closely allied to *Ophiochœta*.

West Indies, in 160 to 576 fathoms, Blake Exped.

*Bulletin Mus. Comp. Zoöl., vol. x, p. 256, pl. v, figs. 70–72 (as *Ophiacantha*).

Ophiopristis Ver., 1899*a*, pp. 39, 44, 47. Type, *O. hirsuta* (Lym.) Ver.

Adoral plates elongated, three-lobed; the distal end is two-lobed; one distal lobe joins the first under arm-plate; the other joins the first side arm-plate and separates it from the oral shields, so that the oral shield is quite detached from the side arm-plates, as in *Ophiocopa*. Disk-scales bear spinules or granules. Radial shields are separated, mostly concealed by cuticle. Arm-spines rather long; in the typical group, mostly flattened and with regularly serrulate edges. The rows are not approximate dorsally. Tentacle-scales one or two.

Tooth-papillæ two to four. Oral papillæ numerous; two or more of these are special oral tentacle-papillæ or scales, guarding the large outer oral tentacle-pore, which is on or near the margin of the jaw and is conspicuous. First under arm-plate is concave and has a flat process on each inner corner.

Synoptical table of Ophiopristis and Ophiotreta.

A.—Typical *Ophiopristis*. A row of several small conical or slender, distal, oral tentacle-papillæ outside the large pore. Arm-spines partly flat with serrulate edges. Two or three tooth-papillæ. Dorsal arm-plates separated, but rows of spines not approximate.

O. hirsuta Lym. (See p. 336.)

O. ensifera Ver. (See p. 336, Pl. XLIII, fig. 4.)

O. cervicornis Lym. A regular row of four or five slender oral tentacle-papillæ. Two tooth-papillæ. Two spiniform tentacle-scales; the pores very large and open. Disk and radial shields covered with fine granules and small acute spinules; some spinules on upper arm-plates. Six short flat spines serrate on the edges.

AA.—*Ophiotreta* Verrill, 1899*a*, p. 40. (See p. 333.) Spines terete or only little flattened. One or two, rarely three, distal oral papillæ or scales at the large oral tentacle-pore. Two to five or more tooth-papillæ.

a.—Dorsal arm-plates joined. Rows of spines not approximate dorsally. Spines nearly smooth. Tooth-papillæ three to five. Distal oral tentacle-scales flat, blunt, two or three. Two tentacle scales on several basal joints; one is flat, the other spiniform.

O. lineolata (Lym.). Disk and radial shields closely covered with granules and spines. Jaws bear granules. Arm-spines seven.

aa.—Dorsal arm-plates separate. Rows of spines not closely approximate. Two or three tooth-papillæ. Spines nearly smooth or finely serrulate or thorny; some a little flattened.

O. sertata (Lym.). Arm-spines seven. Tentacle-scale large, flat. Two flat, distal, oral scales. Disk covered with granules and tapered spines. Radial shields sometimes naked, ovate, separate, but usually concealed.

O. Valenciennesi (Lym.). Tooth-papillæ three; oral tentacle-pore large, marginal, with a large round distal scale ; a pair of small papillæ on first under arm-plate ; two large tentacle-scales. Spines four, with blunt thorny tips. Disk granulated.

To this group may also be referred *O. placentigera* (Lym.), off Fiji Is., 1350 fath. It has three tooth-papillæ ; a large, broad, oral tentacle-scale; granulated disk ; six smooth spines ; one tentacle-scale.

Amphipsila Verrill, 1899*a*, p. 55. Type, *A. maculata* Ver.

PLATE XLIII. FIGURES 5, 5*a*.

Disk rounded, covered with thin, naked scales, above and below. Radial shields narrow, separated, naked. Arm-plates distinct, above and below. Arm-spines of moderate length, numerous (five to twelve), serrulate. Oral shields clearly visible, at least when dry. A simple row of oral papillæ. Only two or three conical apical papillæ, in a row; these may be considered as tooth-papillæ, but there is no distinct cluster of inner tooth-papillæ, below the teeth, as in *Ophiopsila*. Tentacle-scale spiniform.

I have separated this genus from *Ophiopsila*, as understood by Lyman, for he included in the latter *A. fulva* (Lym.), which is closely allied to our type-species.

In true *Ophiopsila* (type, *O. aranea*), to which *O. Riisei* of the West Indies also belongs, there is a cluster of many special tooth-papillæ, within the mouth, below the teeth, as in *Ophiocoma*, and the disk is covered with thick cuticle, nearly or quite concealing the scales. It appears to belong to the family *Ophiocomidæ*, while our genus seems to be closely related to *Ophiacantha*, with which it agrees in its mouth-parts and spines. It differs from typical *Ophiacantha* it its naked disk-scales and radial shields, in having the upper arm-plates joined, and in the distal prolongation of the adoral plates, much as in *Ophiopristis* and *Ophiolimna*, though less distinct, owing to its narrowness.

Ophiomitra Lyman.

Bulletin Mus. Comp. Zoöl., vol. i, p. 325, 1869; Voyage Challenger, v, pp. 202–209, 1882, pl. xlv, figs. 4–6, (anatomy).
Verrill (restricted), Oph. Bahama Exped., Bull., v, p. 57, 1899.

This genus is very closely allied to *Ophiacantha*. The only special distinctions given by Lyman are the larger size and nakedness of the radial shields and the naked or nearly naked scales of the disk.

Mr. Lyman also described the disk of the type-species as rounded and cap-like,—a character due, perhaps, to immaturity, for in large specimens of that species the interradial margins are incurved or emarginate.

When adult the type-species (*O. valida* Lym.)* has numerous spiniform, clustered oral papillæ and tooth-papillæ. The distal oral tentacle-pore is large and sub-marginal, partly sheathed by proximal processes from the concave first under arm-plate and inner side of the jaw. The adoral shields are very broad, but wholly proximal to the small oral shields. The basal tentacle-pores are larger and furnished with two prominent tentacle-scales. The large, broad radial shields are largely in contact. The disk-scales are not large, of nearly uniform size, without specialized marginal ones, and bear coarse, short, clavate, thorny stumps. The arm-spines are numerous, somewhat thorny and glassy. The dorsal arm-plates are slightly separated by the side-plates.

Most of the species subsequently described by Mr. Lyman and others differ much from the type, in several characters.

They nearly all have a single odd tooth-papilla and a simple row of oral papillæ, as in typical *Ophiacantha*. The interradial marginal scales are usually large and specialized. The radial shields are often entirely separate and in some cases not particularly large.

In fact, they have little in common with the type, except the partial nakedness of the radial shields and disk-scales,—characters also found in species of *Ophiacantha*.† Therefore it seems necessary to subdivide the genus.

* The specimens originally described and figured by Lyman were all immature, and had not developed the true character of the mouth-parts.

† One species (*O. Normani*) referred to this genus by Mr. Lyman does not agree with it even in these characters, for the separated radial shields are no larger and no more exposed than in several species of *Ophiacantha*, and its disk-scales are granulated. In its arm-spines, which are smooth and only four in

Ophiotrema of Kœhler seems to be very closely related to typical *Ophiomitra.*

Like the latter, it has clustered tooth-papillæ and oral papillæ, with a large, conspicuous distal oral tentacle-pore and special papillæ around it. The tentacle-pores are large and surrounded by several small acute spinules. Disk-scales are small, visible, bearing acute rough spinules. Radial shields are small, naked, separate, divergent. Arm-spines five, serrulate.

O. Alberti Kœhl., '96, the type, is from off the Azores.

Certain species referred to *Ophiomitra* by Kœhler appear to belong to *Ophiomitrella.* (See p. 352.)

Synoptical table of the species that have been referred to Ophiomitra (sens. ext.) *and Ophiomitrella.*

Group A.—Typical *Ophiomitra.*

Tooth-papillæ several, clustered. Oral papillæ numerous, clustered distally. Distal oral tentacle-pore large. Radial shields large, naked, usually joined. Disk-scales visible, all of moderate size, bearing stumps or spinules. Arm-spines thorny and usually glassy. Two or three tentacle-scales on the basal joints, in the type. Adoral shields broad, proximal to the oral shields. Interradial margins of disk somewhat incurved, sometimes convex, not deeply notched.

a.—Radial shields largely in contact.

b.—Disk-scales bear short clavate or capitate stumps. Rows of arm-spines not approximate dorsally.

O. valida Lym., '69. Arm-spines nine or ten, solid, not very long, roughly serrulate or thorny.

bb.—Disk-scales bear longer and shorter, tapered, thorny spines. Rows of spines approximate dorsally.

O. ornata Ver., 1899*a*. This Vol., pl. XLIII, fig. 3. Arm-spines long, slender, thorny.

aa.—Radial shields divergent, in contact only distally. Arm-plates separate above and below.

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number, it differs from all the species of *Ophiomitra*. Therefore I have referred it to *Ophiacantha*, with which it agrees in its mouth parts. (See p. 329.)

Another species (*O. exigua* Lym.) I refer to *Ophiothamnus.* (See p. 328.) This, also, has smooth spines, and the small oral shield is separated from the side arm-plates by the large adorals.

**O. spinea* Ver. Oral papillæ not very numerous distally. Disk-scales small, with small conical spinules. Arm-spines eight or nine, rough, hollow, the rows not approximate dorsally. One or two tentacle-scales.

AA.—*Ophioplinthaca*, gen. nov. Type, *O. dipsacos* Lym. One odd tooth-papilla, oral papillæ in a nearly simple series, not clustered distally. Interradial margins of disk notched or deeply emarginate. Marginal and submarginal disk-scales large and specialized. Arm-spines thorny and glassy, usually hollow. Radial shields large and broad, naked or nearly so. First tentacle-pore decidedly larger, with two or more scales. Oral shield joins the first side arm-plates.

B.—Radial shields in contact along most of their length. Rows of spines not approximate dorsally.

c.—Upper arm-plates distinctly separated by the side plates.

O. dipsacos (Lym.). Arm-spines six, hollow, very thorny, the two upper ones very long. First tentacle-pore with two scales.

cc.—Upper arm-plates on basal joints slightly joined, or barely separate. Two or more distal oral tentacle-scales, similar to other oral papillæ.

O. incisa (Lym.). Arm-spines five or six, flattened, thorny on edges. Three to six tentacle-scales at first pore, one or two farther out. Disk-scales with few, nearly smooth, conical spinules.

BB.—Radial shields not in contact, or only slightly so distally. Spines glassy and thorny, the rows not approximate dorsally.

d.—Radial shields in contact at the distal ends, very large and wide.

e.—Upper arm-plates separated.

O. carduus (Lym.). Spines six, very thorny. Disk-scales with thorny stumps, marginal scales very large. Tentacle-scale one, lobate.

ee.—Upper arm-plates, on basal joints, not separated by side plates. First tentacle-pore larger, with two or three scales. A flat oral tentacle-scale.

O. plicata (Lym.). Radial shields joined distally in young; separate in adult. Disk-scales with small, conical spinules. Arm-spines

five or six, short, very thorny. Distal edge of under arm-plates bent downward.

dd.—Radial shields well apart, with intervening rows of scales.

f.—Upper arm-plates not separated by the side plates. Two tentacle-scales on first joint.

O. Sarsii (Lym.). Radial shields rather small, far apart. Disk-scales with small conical spinules. Arm-spines seven or eight, very thorny. Tentacle-scale lobate. A stout oral tentacle-scale.

ff.—Upper arm-plates separated by the side plates. Disk-scales coarse; marginal ones larger.

O. chelys (Lym.) Radial shields narrow, sunken. Disk with small conical spinules. Arm-spines six, hollow, very thorny. One tentacle-scale.

AAA.—*Ophiomitrella* Ver., 1899*a*, p. 39. (See p. 343.) Radial shields small, wide apart, naked. Disk-scales all nearly alike, not very large, outlines easily visible. One tooth-papilla. Oral shields join the side arm-plates. Interradial margins of the disk not deeply emarginate and without large scales. Disk bearing scattered granules or stumps.

g.—Arm-spines serrulate, the rows not approximate dorsally.

O. globulifera (Kœhler, '95). Arm-spines five. Disk-granules glassy, spherical. Europe, 1700 meters.

O. cordifera (Kœhler, '96). Arm-spines six or seven. Disk with small capitate granules. Azores, 1143 meters.

gg.—Arm-spines thorny and glassy, the rows approximate dorsally. A special outer oral tentacle-scale on the first under arm-plate.

O. lævipellis (Lym., as *Ophiacantha*). Seven or eight spines. Disk-scales naked or sparsely granulated ; all small. Disk pentagonal. (See also page 343.)

O. cornuta (Lym., as *Ophiacantha*). Spines eight. Disk rounded, bearing small thorny stumps; a larger scale between the radial shields. (See p. 339, note.)

AAAA.—Radial shields very large and in contact, covering most of the disk. Oral shields small, triquetral, not joining the side arm-plates; adorals large and broad. Arm-spines smooth or nearly so, the rows not approximate dorsally.

O. exigua (Lym.). Disk-scales few, coarse, with few thorny stumps. Arm-spines six, rather short, tapered; oral papillæ three, the outer one on the adoral shield. Tentacle-scale one.

The last named species should, I think, be referred to *Ophiothamnus*, with which it agrees well in all external characters. (See p. 350.)

O. Normani Lym., omitted from the table, is to be referred to *Ophiacantha* (typical group) as already stated (p. 349, note). It has small and rather widely separated radial shields and four smooth arm-spines.

Ophiomitra valida Lyman.

Ophiomitra valida Lyman, Bull. Mus. Comp. Zool., i, 10, p. 325, 1869; op. cit., x, p. 264, 1883; Lyman, Ill. Cat. Mus. Comp. Zool., vi, pl. ii, figs. 4–6; Lyman, Report Voy. Challenger, Zool. Ophiuroidea, v, p. 209, pl. xli, figs. 4–6, 1882.

Ophiomitra cervicornis (young) Lyman, Ill. Cat. Mus. Comp. Zool., viii, pt. ii, p. 14, pl. ii, figs. 19, 20, 1875; Bull. Mus. Comp. Zool., vol. v, part 9, p. 231.

Ophiomitra valida Verrill, Ophiur. Bahama Exped., Bull., v, p. 58, 1899.

Several large specimens of this species, sent by Mr. Lyman, differ considerably from his figures and description, which were made from immature specimens.

The most important differences are found in the mouth-parts. The largest of our specimens have very numerous oral papillæ and tooth-papillæ, crowded together in clusters, very much as in *Ophiocamax*. The tooth-papillæ often consist of a row of three, on or below the margin, and of two or three pairs above these, next the teeth, but frequently they are so crowded that no such regular arrangement can be made out. There may be as many as nine or ten on one jaw-apex. The distal oral papillæ form crowded groups of four to seven, or more, or they may stand in two rows, so as to cover or conceal most of the width of the jaw. They are all rather stout, spiniform, subacute. The distal oral tentacle-pore is large, marginal, exposed, nearly surrounded by sheath-like processes of the jaw and first under arm-plate, which is small and deeply concave. The oral tentacle is large, with a thickened basal part into which the distal part can be retracted.

Tentacle-scales two or three on the basal joints; farther out the pores and scales decrease in size rapidly. On the basal joints the inner scale is large, flat, lanceolate, erect, hollowed out on the side next the tentacle; the other is narrow, subacute. The under arm-

plates are smaller on the basal joints than farther out. They are broader than long, with a concave emargination on the distal edge.

The dorsal arm-plates are rather quadrant-shaped, with a broad lobe on the distal edge, and with prominent lateral angles. Some of the basal arm-plates are slightly in contact. Arm-spines ten, rather stout, roughly serrulate, blunt, the rows not approximate dorsally. The radial shields are larger, irregularly triangular, more or less encroached upon by the disk-scales and granules. The disk-scales are not large, all nearly equal, sparsely covered with short, coarse, rough, capitate stumps. The interradial margins have a small notch in dried specimens, but not larger scales.

Oral shields small, pelecoidal, with an acute inner angle, and a prominent convex outer end. Adorals about as large as the orals, wide, lunate, the surface finely granulous in appearance. In younger specimens the distal oral papillæ form one irregular row of about three or four around the pore.

Common throughout the West Indies in 10 to 1105 fathoms (Blake Expedition).

OPHIOCAMAX Lym. Type, *O. vitrea* Lym.

Ophiocamax Lym., Bull. Mus. Comp. Zool., vol. v, p. 156, 1878; Voy. Challenger, v, p. 209, 1882.

This genus is closely allied to typical *Ophiomitra*. Like the latter it has numerous tooth-papillæ in an apical cluster, and a cluster of distal oral papillæ, even more numerous than in *Ophiomitra*.

In the type-species there is also a special small distal plate (process of under arm-plate?) which bears two or three small papillæ directed proximally and serving as part of the papillæ for the large oral tentacle-pore.

The basal tentacle-pores have three or four elongated, erect tentacle-scales forming a sheath for the tentacles. Radial shields are wide and in contact. Disk-scales, which are usually visible, bear thorny spinules, but in the type species they are scarcely visible and closely spinulose in the adult.

The adoral shields are large and broad, situated in front of the oral shields.

Synoptical table of the species of Ophiocamax.

A.—Typical. Dorsal arm-plates, at base of arm, not separated by the side-plates. Rows of spines not approximate dorsally.

O. vitrea Lym. Disk closely covered with small, acute spinules, the scales nearly concealed. Tooth- and oral papillæ very numerous, slender, acute. Nine thorny arm-spines. Tentacle-scales large, obtuse.

O. hystrix Lym. Disk-scales visible, irregular, bearing few, short, conical, rough spinules. Radial shields in contact distally. Arm-spines eight, slender, the upper ones very long.

AA.—Dorsal arm-plates all separated. Rows of spines not approximate dorsally.

O. fasciculata Lym., '83. Arm-spines six, rather short, flattened, serrulate on the edges. Disk-scales plainly visible, bearing few small, tapered, acute spinules. Radial shields not very large, broad, wholly in contact. Dorsal arm-plates widely separated.

O. austera Ver., Ophiur. Bahama Exped., p. 60, pl. vi, figs. 1, 1*a*, pl. vii, fig. 2. Arm-spines seven, slender, the upper ones very long and very thorny, scarcely flattened. Disk-scales visible, bearing longer and shorter, rough, acute spinules. Radial shields large, triangular, extensively joined. Dorsal arm-plates nearly in contact on the basal joints. Four lanceolate tentacle-scales. A cluster of about six acute, distal, oral papillæ, pointing inward on each side, part of them arising from the lateral lobes of the deeply bilobed first under arm-plate. (See this vol., Plate XLIII, figure 2.)

OPHIOCHONDRINÆ, subfam. nov.

This group differs from typical Ophiacanthidæ chiefly in having the internal arm-plates so modified that the arms can be coiled in a vertical plane, like the *Astrophytons*, etc. The arm-spines are short, subequal, not very rough. The disk-scales may be thickly covered with cuticle and granules, or they may be naked. The oral papillæ are few, in a simple row. The thick cuticle sometimes covers the mouth shields and lower side of the arms.

The modifications of the ambulacral ossicles fits these species more perfectly for clinging closely to gorgonians, etc., by coiling the arms closely around the branches. But this power is also common to various species of *Ophiacantha*, in a lesser degree.

Ophiochondrella Ver., gen. nov. Type, *O. squamosus* (Lym.).

This differs from true *Ophiochondrus* in having the disk covered with naked scales, above and below; in having the under arm-plates

covered and concealed by thick cuticle; in having the under arm-plates in contact; and in having two tentacle-scales.

The arm-spines are short, nearly equal. Radial shields naked, ovate, and separate.

Ophiochondrella squamosus (Lym.).

Ophiochondrus squamosus Lym., Bull. Mus. Comp. Zool., x, p. 275, pl. vii, figs. 108–110, 1883.

The disk-scales are thick, swollen, irregular. Arm-spines eight, tapered. Oral papillæ three, small, spaced. Tentacle-scales minute, rounded. West Indies, 250 fathoms, Blake Exped.

Ophiochondrus Lyman.

Bulletin Mus. Comp. Zool., i, p. 328, 1869; Voy. Challenger, p. 247, 1882. Type, *O. convolutus* Lyman.

The characters given to this genus by Mr. Lyman should be modified by adding that there are two or three nearly vertical plates at the base of the arm, supporting the ends of the radial shields, so that the edge of the disk is considerably raised above the arm, making a sharp angle with it. The radial shields are still more strongly supported by an elongated genital plate, running up each side of the genital slits and joining the radial shields.

Ophiochondrus crassispinus Lyman.

Ophiochondrus crassispinus Lyman, Bulletin Mus. Comp. Zool., vol. x, p. 275, 1883.

Several specimens from the Blake Exp., Station 232, 88 fath., off St. Vincent, were sent to the Yale Museum by Mr. Lyman under the name of *O. convolutus*, under which they are also evidently recorded in Mr. Lyman's lists of 1883.

These, on careful study, appear to belong to *O. crassispinus*, as defined and figured by Mr. Lyman. The latter was described from a single specimen, from 229 fath., Blake Exp.

They have three acute, conical, oral papillæ, exclusive of the odd terminal one. The oral shield is small, thick, pear-shaped, with an acute proximal angle; arm-spines six or seven, short, nearly equal. A very small acute tentacle-scale is usually present in the larger specimens. Upper arm-plates on proximal part of arm, except two basals, are nearly quadrant-shaped with the outer edge convex and the lateral angles acute; distally they become more nearly triangular, with the sides a little convex.

The radial shields are large, elongated, separated by a band of small flat scales. Central part of disk and interradial spaces covered by very small, flat, naked scales. The arms are relatively stout, of moderate length, tapering rapidly.

O. convolutus L. is described as having the disk granulated ; oral papillæ four and squarish ; oral shield broader ; radial shields shorter and broader ; besides other differences. Possibly the two forms may be only variations of one species, but none of my specimens are intermediate.

One of the specimens from Station 232 was clinging closely to a group of Zoanthoid corals (*Epizoanthus*). The genus is evidently adapted to living clinging to *gorgonians* and similar organisms, for protection.

Family, **OPHIOSCOLICID** Ltk., 1869.

Ophiomyxidæ (*pars*) Ljung., 1866.
Ophioscolicinæ (sub-family) Ljung., 1871.

The upper side of the arms is covered with naked skin, beneath which the arm-bones can usually be seen. Under arm-plates and side arm-plates are present, though sometimes much degenerated. Arm-spines are moderately long, often rough or thorny, two to six in number. Tentacle-scale often wanting, but three or four are present in *Ophiambix*. Oral papillæ are usually numerous and form a continuous row, but sometimes they are few, and rarely lacking (in *Ophiobyrsa*). Tooth-papillæ usually lacking, rarely present as irregular spiniform papillæ. Teeth simple, spiniform.

Disk covered with a soft skin, which may contain minute scales and may bear granules or spinules. Radial shields small or rudimentary, sometimes lacking. Oral and adoral shields normal.

Internally the arm-bones of *Ophioscolex* are deeply grooved ventrally and dorsally and cut away laterally at the ends ; the mouth-frames are reduced and simple, but the peristomial plates are large and in three pieces.

In some of the other genera the arm-bones are more rudimentary. In *Ophiogeron* and *Ophiosciasma* they are entirely separated, along the median plane, in two elongated parts, curved towards each other. This is an embryonic character, illustrating the relatively low development of the skeleton in this family.

This family, as now known, seems to be more nearly allied to *Ophiacanthidæ* than to *Ophiomyxidæ*, with which it was formerly united.

Externally there are no tangible characters to distinguish this family from certain of the *Ophiacanthidæ*, except the lack of upper arm-plates, which are always present in the latter. But the internal structure, so far as studied, is peculiar.

The family, as here understood, includes the following described genera: *Ophioscolex*, *Ophiosciasma*, *Ophiogeron*, *Ophiobyrsa*, and *Ophiambix*.

Certain species that have been referred to some of these genera do not agree in structure with the typical species, and therefore I have established two new genera for their reception:

Ophiobyrsella, gen. nov. Type, *Ophiobyrsa serpens* Lyman.

Astrogeron, gen. nov. Type, *Ophiogeron supinus* Lyman.

Ophioscolex fragilis Ver., sp. nov.

Five slender arms. Oral shield small, narrow, pear-shaped, with an acute proximal angle. Adoral shields narrow, oblong, the inner end acute and touching. Oral papillæ six or seven, forming a row which is not regular in the middle; the two outer ones are larger than the others, tapered, acute; the four inner ones, which do not lie in just the same line, are small, slender, acute. Lower arm-plates hour-glass-shaped, narrow, longer than wide, truncated at the ends and closely joined, and apparently soldered with the side plates. Arm-spines three, slender, tapered, acute, nearly equal, about as long as a joint. Tentacle-pores large. No tentacle-scale. The disk is destroyed in my specimens.

Diameter of the disk-scar, 10^{mm}; length of arms, 22^{mm}.

Off Barbadoes, Station 293. Blake Exp., 82 fathoms.

Ophiobyrsella Ver., gen. nov. Type, *O. serpens* (Lym.).

Disk pentagonal, covered entirely by naked skin, which hides the oral and adoral shields and extends out over the upper and under sides of the arms and spines. Small spinules are situated over the region of the radial shields and along the margins of the disk, or over the whole disk. No tentacle-scales; tentacles large. Arm-spines three to five,—three in the type; rough, glassy. About five spiniform teeth. Oral papillæ form a regular lateral row, besides two or three tooth-papillæ at the tip of the jaw.

This genus is very near *Ophioscolex* in external characters.

True *Ophiobyrsa* (type, *O. rudis*) differs in having only one oral papilla, no teeth, and only a few spiniform tooth-papillæ; these parts being very much reduced.

Ophiobyrsella serpens (Lyman) is from the West Indies, in 69 fathoms.

Another species, *O. hystricis* (Lyman), with five slender and rather long spines, was dredged off the Shetland Islands, in 345 fathoms. (Bulletin Mus. Comp. Zool., vol. x, p. 272, Pl. viii, figs. 120–122, 1883.)

Astrogeron Ver., gen. nov. Type, *Ophiogeron supinus* Lym.

Disk and arms covered by a naked skin containing minute scales; beneath the skin are small rounded radial shields and very short genital plates and scales. Teeth small, spiniform; a cluster of spiniform tooth-papillæ at the end of the jaw, and a row of oral papillæ on the edge. Oral and adoral shields normal. No tentacle-scale. About two slender, glassy arm-spines covered by skin. Arm-bones divided longitudinally. The typical species of *Ophiogeron* has no oral papillæ, the jaw-plates being naked except for a few small spiniform teeth at the tip, but, otherwise, it agrees pretty closely with this.

Astrogeron supinus (Lym.) is from the West Indies, in 200 to 464 fathoms.*

Mr. Lyman has described several very remarkable genera, allied in some respects to *Ophioscolecidæ*, but presenting such peculiar structures that it does not seem reasonable to refer them to any of the described families. They should be considered as types of two distinct families, if the differences that separate families in other cases are taken as our criteria. In fact, they present greater diversities than can be found elsewhere in the entire group of regular Ophiuroids. Therefore I propose to classify them as follows:

Ophiomycetidæ, fam. nov.

Sub-family, *Ophiomycetinæ*, nov. Type, *Ophiomyces* Lyman.
Sub-family, *Ophiotholinæ*, nov. Type, *Ophiotholia* Lyman.

Ophiohelidæ, fam. nov. Type, *Ophiohelus* Lyman.

These groups will be described on subsequent pages.

Family, **OPHIOMYCETIDÆ**, nov.

Disk swollen, covered with scales, which may be either naked or spinulose. No radial shields. Teeth few. Two, three, or more apical tooth-papillæ. Oral papillæ numerous, the outer ones large,

* Bulletin Mus. Comp. Zool., vol. x, p. 270, Pl. vii, figs. 103 to 106, 1883.

flat, foliate or spatulate, recurved, in two or more divergent rows or clusters, partly on the adoral plates. The arms can be turned up vertically above the disk.

Sub-family, **Ophiomycetinæ**, nov.

Disk with small but distinct scales, usually spinulose. No grapel-shaped spinules on the arms. Arm-spines of the basal joints, and sometimes the lower ones on some of the joints beyond the disk, are flattened or spatulate ; others are long and slender. Tentacle-scales of basal joints flat, often multiple. Upper arm-plates small, separated. Side plates large, meeting above and below. Oral shield small. Adoral shield long, carrying many of the spatulate oral scales.

Internal mouth-frames slender; genital scales and plates broad, flat, and curved up over the base of the arm. Arm-bones well developed, but peculiar in form, and without a distal condyle. The arm can be turned up vertically above the disk.

Only four or five species are known. Two, *O. mirabilis* Lym. and *O. frutectosus* Lym., are West Indian. *O. spathifer* Lym. is from off Japan, in 565 fathoms, and *O. grandis* Lym. is from the South Atlantic, in 1000 fathoms.

Sub-family, **Ophiotholinæ**, nov.

No visible radial shields. Disk-scales delicate, spinulose. Arm-spines present on all joints, slender, about three ; associated with the spines, beyond several basal joints, are clusters of grapel-shaped spinules,* like those of *Ophiohelus*. A simple row of flat oral papillæ and tooth-papillæ surrounds the proximal ends of the jaws. Distally the oral papillæ and oral scales are very numerous, in several divergent rows, recurved, broad, flat, foliate or spatulate, much as in *Ophiomycetes*.

Several spiniform teeth. Tentacle-scales, on the basal joints, two or more, flat; on other joints, spiniform. The side arm-plates meet broadly below. Under arm-plates covered by cuticle.

This group is closely allied to *Ophiomycetinæ*, from which it differs mainly in having grapel-shaped spinules on the distal joints and in the more simple arm-spines.

*Mr. Lyman describes these as "pedicellariæ," but they are totally different from all forms of true pedicellariæ. They seem to me strictly homologous with the curved hooks and hooklets of *Astronyx* and allied genera, though much more complex in structure.

Only a single species is known : *Ophiotholia supplicans* Lym., taken off Juan Fernandez, in 1825 fathoms, Challenger Expedition.

Family, **OPHIOHELIDÆ**, nov.

No radial shields. Disk-scales very thin or rudimentary. Arm-bones divided into right and left plates. Oral papillæ spiniform, few, in a simple row. Teeth spiniform. Distal joints of arms bear rows of peculiar grapel-like or "parasol-shaped" spinules, in place of true spines. Only one genus is known.

Ophiohelus umbella Lym.

Mem. Boston Soc. Nat. Hist., 1880, pl. i, figs. 5–10 and 16.

This, the type-species, was taken off Barbadoes, in 82 fathoms.

O. pellucidus Lym.

Op. cit., pl. i, figs. 11–15, 1880.

This species was taken off the Fiji Islands, in 1350 fathoms, Challenger Expedition.

Family, **OPHIOMYXIDÆ** Ljung. (restr.), 1866.

Ophioscolecidæ (*pars*) Lutk., 1869.
Ophiomyxinæ (sub-family) Ljung., 1871.
Ophiomyxidæ Carus, Faunæ Medit., p. 96, 1884. Verrill, Oph. Bahama Exped., p. 65, 1899.

Disk and arms covered with thick cuticle, and usually with only a row of marginal disk-scales, and a few scattered ones imbedded in the cuticle, but visible only when dried. Radial shields small, usually with a proximal series of small supplementary scales.

Teeth and oral papillæ stout, flat, with the end serrated. No tooth-papillæ. True tentacle-scales generally absent. Under arm-plates small. Side arm-plates sub-ventral, bearing several rough divergent spines. Upper arm-plates rudimentary or lacking ; when present, composed of small pieces. Two large, triangular, peristomial plates on each mouth-angle.

Arm-bones peculiar, belonging to the modified "hour-glass-shaped" type, with well-formed condyles on both ends.

Ophiomyxa and *Ophiodera* are the only genera described. The second genus has the following characters :

Ophiodera Verrill, Oph. Bahama Exped., p. 67, 1899. Type, *O. serpentaria* (Lym.).

Marginal disk-scales are rudimentary and concealed by thick cuticle ; the disk-scales proximal to the radial shields are lacking. No upper arm-plates. Side arm-plates may be soldered to the under arm-plates. They are not continued upward by a row of small plates. Three or four arm-spines enclosed in cuticle; the inner one is smaller and may serve as a tentacle-scale; it is sometimes forked distally. Teeth and tooth-papillæ serrate, nearly as in *Ophiomyxa*, but with finer denticles.

Ophiodera Stimpsoni Verrill.

? Ophioscolex Stimpsoni Lyman, Illust. Cat. Mus. Comp. Zool., viii, p. 23, pl. i, figs. 11-15, 1875.

Ophiodera stimpsoni Ver., Oph. Bahama Exped., p. 67, pl. ii, figs. 4, 4*a*, 1899.

Plate XLII. Figures 2, 2*a*, 2*b*, 2*c*.

Arms very long and slender. Disk five-lobed, the lobes extending out a little on the base of the arms. Teeth three or four; upper one stout, spiniform, the others thicker, subtruncate.

Whole upper surface of disk and arms and lower surface of disk are covered with thin naked cuticle, wrinkled when dry, containing imbedded, scattered, microscopic scales on the disk, and a row of irregular small, marginal scales. Sometimes there are a few small, irregular granules along the margin and on the under side of the disk, and also on the bases of the arms. Radial shields very small or rudimentary, concealed by cuticle.

Diameter of disk 7^{mm}; length of arms about 45^{mm}.

West Indies, 60 to 240 fathoms.

Oral papillæ about five, partly slender, subspiniform, rough at tip, irregularly crowded in a row, nearly equal in length, but some are flattened and obtuse at tip. Sometimes there is also a somewhat stouter tooth-papilla. Within mouth-slits, on each side, there are two (sometimes only one) slender papillæ between the two oral tentacle-pores.

Genital slits wide and open near the oral shields, but narrow distally and not extending to the edge of the disk, bordered by narrow, naked scales.

Tentacle-pores are small and round. In some specimens there is a small, slender, spiniform tentacle-scale, which is often deeply forked, or even double, and in alcohol is covered with a sheath of cuticle ; it stands nearly in line with the other spines, beside the

tentacle-pore. It is often reduced to a minute spinule, and is frequently absent.

Arm-spines three or four, divaricate, small, nearly equal, sharp, roughly serrulate and glassy, more or less covered by cuticle when in alcohol.

The internal arm-plates show as transversely rhombic plates separated by wider intervals.

Family, **HEMIEURYALIDÆ** Ver., Oph. Bahama Exped., p. 70, 1899.

In this family are included several genera of true Ophiuræ, which very much resemble, in form and habits, the simple-armed Euryalæ or Astrophytons. Like the latter, they coil their arms closely around the branches of gorgonian corals on which they dwell.

The disk is pentagonal and covered with thick plates or tubercles, which may be conical. The radial shields are large and prominent.

Upper arm-plates may be entire and accompanied by supplementary plates, or they may be replaced by a mosaic of small plates. They are thick or tubercular.

Under arm-plates well formed. Side-plates separated by extra plates. Oral and adoral shields normal. Spines few, short and stumpy. A row of oral papillæ. Teeth, but no definite cluster of tooth-papillæ.

Genital pores small, situated near together at the outer end of the oral shield. Arm-bones have special forms approaching those of the *Astrophytons.* Mouth-frames strongly ossified.

The genera belonging to this family are *Hemieuryale*, *Ophioplus*, and *Sigsbeia.*

Hemieuryale pustulata Von Martens.

Hemieuryale pustulata Von Mart., Monatsb. Konig. Akad. Berl., p. 484, 1867; Ljung., Dr. Goes., Oph., Ofv. Kong. Akad., p. 617; Lyman, Ann. Sci. Nat., xvi, Art. 4, p. 5; Bull. Mus. Comp. Zool., iii, 10, p. 268, pl. v, figs. 8–11; op. cit., x, p. 277; Report Voy. Challenger, Zool. Ophiuroidea, v, p. 249, pl. xliii, fig. 7–10 (anatomy), 1882.

Ophiura cuspidifera (?) Lamk., Hist. Anim. s. Vert., iii, p. 226, 2d ed., 1840; Encyclop. Meth., pl. cxxii, figs. 5–8.

Disk small, thick, swollen, pentagonal, with a swelling opposite the base of each arm when dried; whole surface, except radial shields, covered with larger and smaller thick scales and verrucæ. The central primary scale is round and rough like the radial shields, but not swollen. Five primary rounded radial scales, which are

larger than the rest, are strongly convex or pustular, and often white. Five somewhat smaller convex interradials may usually be distinguished by their size; the other plates and scales are of various sizes, the larger ones convex or somewhat verruciform, while the small ones are nearly flat. A radial band of small scales extends continuously between the radial shields and out over the upper side of the arms, becoming flat, angular, and closely crowded on the arms, so as to form a fine mosaic.

Radial shields long-ovate, widely separated; the surface is evenly covered with fine hemispherical elevations; the side arm-plates are ornamented in a similar manner. Along each side of the arms, above, there is a row of elevated, verruciform or almost hemispherical plates, alternating with the side arm-plates; part of these are usually pure white, alternating with others that are deep brown. Under arm-plates well developed, trapezoidal, with acute outer angles, and with a rather deep median emargination or notch in the distal edge, except on six or seven basal ones; close to the base they are larger than broad, but farther out they become broader than long. Arm-spines generally two, small, short, nearly equal, obtuse, becoming longer and more slender distally. Tentacle-scale rather large, ovate, obtuse. Oral shield large, often white, somewhat "spade-shaped" with the outer end and sides, evenly rounded, the inner edges concave, the median and inner lateral angles acute; they vary considerably in different specimens. Adoral shields swollen, somewhat crescent-shaped or pear-seed-shaped, with the acute inner ends touching. Oral papillæ about five, angular, crowded in a close series, the outer ones larger. Genital openings small, like an angular pore, between two angular plates, at the outer edge of the oral shields.

Color reddish or yellowish brown, spotted and blotched with clear white in various ways, so as to closely imitate the color and appearance of certain species of *Gorgonella* to which it habitually clings. Usually there are rows of white verruciform plates along the arms on the upper side, resembling in size and color the verrucæ of the coral, which has a brown ground-color, like that of the *Hemieuryale*. Part of the tubercular plates of the disk, part of the oral shields, part of the spines, and part of the side arm-plates are also usually white.

Common in water of moderate depth throughout the West Indies wherever the *Gorgonella* lives. Specimens from off Barbadoes have been in the Yale Museum many years. Taken by the Blake Expedition in 74 to 180 fathoms.

Ophioplus Verrill, Ophiur. Bahama Exped., p. 70, 1899.

Type, *Hemieuryale tuberculosa* Lyman.

Disk small, pentagonal, thick, covered with small, thickened or tubercular scales. Radial shields large, naked, separated. Oral shields and adoral shields well developed and naked. Oral papillæ in regular series. No tooth-papillæ. Under arm-plates rather large. Upper arm-plates entire, swollen and well formed, separated by a transverse row of small, tubercle-like plates. Side arm-plates prominent, separated above by a supplementary lateral plate. Arm-spines short, two or three in a row. Tentacle-scale single. A pair of small, round genital pores under the outer end of the oral shields.

This genus differs decidedly from *Hemieuryale*, to which it is allied, in having distinct and well formed dorsal arm-plates. It is also closely allied to *Sigsbeia*. In fact, it stands between these two genera in several characters.

Ophioplus tuberculosus (Lym.) Ver.

Hemieuryale tuberculosa Lyman, Bull. Mus. Comp. Zool., vol. x, p. 276, pl. viii, figs. 120–127, 1883.

Ophiomusium (?) Nutting, Narrative, p. 78.

Ophioplus tuberculosus Ver., Ophiur. Bahama Exped., p. 71, pl. i, figures 1–1*b*, 1899 (description).

Plate XLIII. Figures 6–6*d*.

Color deep brown, variously spotted with whitish, imitating the colors of *Gorgonella* to which it clings.

Usually many of the more prominent verruciform plates of the upper side of the arms and disk are white; under arm-plates dark brown.

Taken by the Blake Expedition in 96 and 115 fathoms; Bahama Expedition, Station 15 and 16, off Havana, 200 fathoms.

Sigsbeia murrhina Lyman.

Sigsbeia murrhina Lyman, Bull. Mus. Comp. Zool., v, 9, p. 234, 1878, pl. iii, figs. 55, 58; op. cit., x, p. 277; Lyman, Report Voy. Challenger, Zool., Ophiuroidea, v, p. 250, pl. xliii, figs. 4–6, 1882, anatomy; Three Cruises of the Blake, ii, p. 114, fig. 399, 1888. Nutting, Narrative, p. 79. Verrill, Oph. Bahama Exp., pp. 72, 73, pl. ii, figs. 1, 1*a*, 1899 (Young, description.)

Plate XLII. Figure 7.

This species clings to gorgonians, which it imitates by the form of its arms and the tuberculated surface of the disk, and probably also in color, when living. Our figure represents a young specimen, which differs considerably from the adult.

Family, **OPHIOBRACHIONTIDÆ** Verrill, nov.

Disk entirely covered with acute spinules and cuticle, without radial shields or ribs. Arms long, slender, serpentine, so covered with cuticle that the plates are hidden. Under arm-plates are present. Side arm-plates not prominent, bearing rows of small double hooks on all the joints, but no spines. Upper arm-plates rudimentary or lacking. Tooth-papillæ spiniform, in an apical cluster; a few similar mouth-papillæ.

The only species, *Ophiobrachion uncinatus* Lym., is from off Cuba, in 250 fathoms.

Order II, **EURYALÆ** Müll. and Trosch., 1842.

Euryalidæ Gray, Synop. Brit. Mus., p. 63, 1840.
Astrophytonidæ Norman, Ann. and Mag. Nat. Hist., xv, p. 104, 1865.
Phytastra Hæckel, Gen. Morph., ii, p. 67, 1866.
Astrophytidæ Lyman, Ljungman, and others.
Euryalæ Müll. and Troschel, Syst. Aster., p. 85, 1842. Ljung., Oph. Viv., p. 334, 1867. Carus, Fauna Medit., p. 97, 1884. Verrill, Ophiur. Bahama Exped., p. 73, 1899.
Cladophiuræ Bell, Proc. Zool. Soc. London, p. 180, 1892; Catal. Brit. Echinod., p. 26, 1892.
Euryalida of several authors.

Family, **EURYALIDÆ** (*pars*) Gray, 1840, restricted.

Astrophytidæ (*pars*) Lyman, and many other authors.

Arms more or less dichotomous. Disk covered with cuticle and granules, and having ten strong radial ridges.

Teeth strong and large, in a single vertical row, as in Ophiuræ. Tooth-papillæ, few or none. Oral papillæ minute, papilliform, or lacking. Adoral shields and jaw-plates large, well formed. Oral shields rudimentary.

Under arm-plates simple; they extend the whole length of the arm. Side arm-plates small, appressed proximally, but prominent or erect distally, where they bear double claw-like hooks and thorny spinules; toward the base of the arms they bear few, small, rough, simple spines or tentacle-scales. Two rows of small plates, extending up from the side-plates, form transverse ridges, around the arms. Large spines, along the upper side of the arm, are borne by some of these plates. Dorsal arm-plates are represented only by small detached pieces.

In having a regular row of teeth and simple normal under arm-plates this group resembles ordinary *Ophiuræ* and differs widely from the *Gorgonocephalidæ*.

Subfamily, **Euryalinæ**, nov.

Arms wide at base, many times dichotomous, with short internodes, bearing two dorsal rows of spines. Disk large, with ten granulated radial ridges. Radial shields long, narrow, composed of only one piece, covered, like the rest of the disk, with cuticle. Interbrachial areas, below, covered with strong united plates.

The type, *Euryale aspera* Lam., is from the East Indies and China Sea.

Subfamily, **Trichastrinæ** Ljung., 1872.

Disk relatively small, but thick, with ten stout radial ribs. Arms angular, stout and high at base, divided only distally into a small number of forks. Tentacle-scales short and stout, about three in a row.

Oral shield well developed.

The type, *Trichaster palmiferus* (Lam.), is from the East Indies.

The arms have two dorsal rows of short, stout, obtuse, conical spines; they generally occur on alternate ridges.

The teeth are very large and thick, with truncate ends. Usually there is a single, large, conical tooth-papilla at the apex of the jaw. Oral papillæ small, papilliform, in two or more rows. The disk and arms, above and below, are rather coarsely granulated.

Family, **GORGONOCEPHALIDÆ** Verrill.

Gorgonocephalinæ (*pars*) Ljung., 1867. Bell, Catal. Brit. Echinod., p. 27, 1892.

Gorgonocephalidæ Verrill (restr.), Ophiur. Bahama Exped., Bull. Univ. of Iowa, v, p. 83, 1899.

Arms divided dichotomously into numerous branches. Disk swollen, with ten prominent radial ribs, covered with cuticle, which may bear granules or scattered spinules, or it may be more or less naked. Radial shields, each composed of several united plates.

The entire surface of the arms and disk above and below is covered with cuticle which is usually granulated, so that the plates are hidden.

Under arm-plates mostly rudimentary, consisting of two or more small pieces, sometimes absent. Side arm-plates are united below

and cover most of the under side of the arms. They bear a row of few, small, rough spines or spiniform tentacle-scales, which are usually hook-like distally. Two or more rows of small plates run up from each of the side plates and form transverse ridges around the arms, covered with granules; these usually bear rows of small glassy hooks. The dorsal arm-plates are rudimentary or wanting.

Teeth and tooth-papillæ numerous, spiniform. Oral papillæ, when present, small, conical or papilliform. Adoral shields well-developed, but usually concealed by cuticle, sometimes broken into several plates. Oral shields rudimentary or wanting. Sometimes there are five small madreporic plates, but usually only one.

The three generic names: *Gorgonocephalus* Leach, 1815; *Euryale* Lamarck, 1816; and *Astrophyton* Agassiz, 1835, were, as originally used and intended, exact synonyms. As now employed, they only date back to Lyman's paper on the Challenger Ophiuroidea, 1878.

That he rightly divided these forms into three distinct genera cannot be doubted, and he doubtless had the right to apply the three names, as he did, to the respective groups, though it might, perhaps, have saved some confusion of nomenclature if he had given new names to two of the genera.

It is certainly useless to go back to Linck, 1733, as the prior authority for *Astrophyton*, for he was not a binomial writer.

For the same reason it is useless to try to restore the ancient pseudospecific names given by Linck and even by Seba (e. g. *costosum*), when later and determinable specific names have been given by binomial writers.

Gorgonocephalus Leach (Zool. Miscell., 1815) is the oldest of the three names under the binomial system. Leach gave a short diagnosis of the genus, and stated that he separated it from *Ophiura* on account of its branched arms. He mentions no special type, but refers to the fact that most writers, following Linné, had referred all the species to "*Asterias caput-medusæ*."

As the latter was primarily based on a species of northern Europe, Lyman's selection of the northern genus to bear this generic name was fully justified.

As for the other two names, since they were synonyms he could have applied each of them to either of the remaining groups with equal propriety, for each name had been used for all the known species.

There certainly is no good reason why Mr. Lyman's usage should not be followed, so far as these genera are concerned.

This family, as here defined, includes only two described genera : *Gorgonocephalus* and *Astrophyton*. To these should be added a third, to include *Euryale verrucosum* Lam., which differs much from both the others. For this I propose the name *Astrocladus*.

Astrocladus Verrill, gen. nov.

Resembles *Gorgonocephalus* in form, but differs in having no pavement of plates on the margins and interradial areas ; in the absence of under arm-plates ; in having no minute hooks on the arm-ridges ; in having no spines or tentacle-scales on the basal points ; in having the side arm-plates more degenerate, and not covering all of the under side of the arms, leaving spaces of naked cuticle between them. The arms have very numerous forks.

The type, *A. verrucosus* (Lam.), has rather large, rounded or verruciform tubercles, arranged in two irregular rows along the upper side of the arms and on the radial ridges of the disk.

There are usually three short, stout, obtuse tentacle-scales, thorny at the tips.

The tooth-papillæ and teeth are very numerous, elongated, spiniform. The oral papillæ form two or more rows; the larger ones are cylindrical or spiniform, the smaller ones conical.

The whole surface of the arms and disk, above and below, is covered with fine and close granules. The annulations of the arms are not very prominent.

The forkings of the arms are very numerous, with short internodes. The arms are stout at the base.

The adoral and oral shields are represented by a group of irregular plates. The interradial areas below are covered with thin granulated cuticle, without plates.

It has been recorded from the Cape of Good Hope, etc. A specimen in the Yale Museum is labeled as from Japan, but this locality may possibly be erroneous.

Family, **ASTROCHELIDÆ** Verrill.

Astrochelidæ Verrill, Ophiur. Bahama Exped., p. 79, 1899.

Arms simple or with a few distal forks, granulated, and also annulated with raised ridges. Disk with five or ten radial ridges, its surface granulated or spinulose.

The genital openings are short, situated toward the margin of the disk, or not close to the inner angles.

Under arm-plates rudimentary or lacking. Side arm-plates cover most of the under surface, but are hidden by cuticle and granules.

They bear a short row of small rough spines or tentacle-scales; above them are double vertical rows of small plates, forming raised ridges and bearing granules and also rows of minute glassy hooks, on the sides and top of the arms. These sometimes extend on the radial ridges of the disk.

Teeth and tooth-papillæ numerous, spiniform; the latter form an apical cluster. Oral papillæ similar in form, sometimes lacking. The teeth may form double vertical rows.

This family includes *Astrochele*, *Astrogomphus*, *Astroporpa*, and *Astrotoma* all with simple arms, and *Astrocnida* with the arms forked near the ends.

Family, **ASTROSCHEMIDÆ** Verrill.

Astroschemidæ Verrill, Ophiur. Bahama Exped., v, p. 76, 1899.

Arms simple, long, slender, coiled. Disk five-lobed, with ten radial ribs; naked or granulated. Radial shields narrow, usually elongated. Under arm-plates small. Upper arm-plates poorly developed, often wanting, sometimes represented by two or more pieces, covered by naked skin or granulated. Side arm-plates relatively large, covering a large part of the lower side of the arm, and usually bearing two elongated spines or tentacle-scales.

Teeth are large, stout, several in a vertical row. Oral papillæ are small or wanting.

Oral and adoral plates, regularly formed, but covered by cuticle. Genital slits short, situated near the outer margin of the disk.

Internal mouth-frames strong, well developed, but without wing-like processes.

This family includes *Astroschema*, *Astrocreas*, and *Ophiocreas*.

Family, **ASTRONYCIDÆ** Verrill.

Astronycina (*pars*) Ljung., Oph. Viv., 1867. Bell, Cat. Brit. Echin., p. 27, 1892.

Astronycidæ Verrill, Ophiur. Bahama Exped., Bull. Univ. Iowa, v, p. 74, 1899.

Arms undivided, long, slender, coiled, not annulated nor granulated. Disk with ten narrow radial ridges formed by long narrow radial shields, covered with thin, smooth scales or naked skin.

Upper and under arm-plates rudimentary or absent. Side arm-plates cover most of the lower side of the arm and project laterally, bearing two, three, or more spines or tentacle-scales, which may be either simple or hook-like. The genital slits are short, near together in a depression near the oral shields.

Teeth stout, well formed, in a single row. Tooth-papillæ one or two, conical, sometimes absent. Oral papillæ small, like conical granules, placed above the margins of the jaw. Oral and adoral plates regularly formed.

Astronyx was the only described genus of this family, till recently, when I added to it a new genus, *Astrodia* (type, *A. tenuispina* Ver.), from deep water off the U. S. coast.

Astronyx Lymani Verrill.

Astronyx Loveni Lym., Bull. Mus. Comp. Zool., vol. x, p. 282, pl. viii, figs. 136–138, young (*non* Müll. and Troschel).

Astronyx Lymani Verrill, Ophiur. Bahama Exped., v, p. 74, pl. viii, figs. 4–4*e*, 1899.

Plate XLII. Figures 6–6*c*.

Arms five, long, slender, coiled. Disk pentagonal with incurved margins, and ten high, long radial shields, which are widely separated, curved outward in the middle and somewhat sinuous distally, the outer end a little clavate or knobbed ; the edge is serrulate with small scales. The radial shields and disk are covered with a thin, smooth skin which extends out on the arms, above and below. Interbrachial region below, in the dry specimen, concave or sunken, with the two short but wide genital openings close together, near the inner angles.

Astrodia Verrill. Type, *Astronyx* (?) *tenuispina* Ver.

Astrodia Verrill, Ophiur. Bahama Exped., p. 74, 1899.

Disk small; arms very long, slender, much coiled. Upper and under surfaces of the disk and arms covered with thin, delicate, closely imbricated scales, without granules.

Under arm-plates not distinct, except on one or two basal joints.

Arm-spines three, except on a few basal joints, rather long, tapered, simple, thorny at the tip, but not becoming hooked, even on the distal part of the arms.

Teeth stout, obtuse, the lowest not differing much from the rest. No tooth-papillæ. A row of small granule-like oral papillæ. Oral and adoral shields well developed.

The type-species lives clinging, by its coiled arms, to a species of slender, pennatulid coral (*Scleroptilum gracile* V.), in 1362 to 2033 fathoms, off the United States East Coast. (See Amer. Journ. Sci., vol. xxviii, p. 219, 1885; and Annual Rep. U. S. Fish. Com. for 1883, p. 550 (as *Hemieuryale tenuispina*).

Part II.—A Faunal Catalogue of the Known Species of Ophiuroidea from the West Indian Region.

In the following article the West Indian Zoögeographical region is taken, in its broadest sense, as extending from South Florida and the Bermudas to Yucatan, and to Pernambuco, Brazil.

The extreme geographical range is here given only for those that are known to extend beyond the West Indian region. When no special localities are given the Carribean Sea and West Indies are to be understood. Those species marked with an asterisk extend northward on our coast.

The synonymy of most of the species is given by Mr. Lyman in the Voyage of the Challenger, vol. v, Ophiuroidea. But dates have been given to indicate the works where the species were first published. Most of these are given on pages 301 and 383. A fuller bibliography will be given with Part III.

I have added references to the excellent woodcuts in the "Three Cruises of the Blake," vol. ii, by Mr. Alexander Agassiz (Bull. Mus. Comp. Zool., vol. xv, 1888); and also to Part I of this series; and to the report on the Ophiuroidea of the Bahama Expedition (1899*a*), when the species or genera are there described or figured.

Order I. **OPHIURÆ** Müll. and Trosch., 1842.

(See this volume, p. 303).

Family, **PECTINURIDÆ** Ver., 1899*a*, p. 4.

(See this volume, p. 303.)

Ophiura Lam., 1801.

brevicauda Lym., '65.		0–35 fath.
guttata Lym., '65.		1–10 fath.
brevispina Say, '25.		1–122 fath.
	Bermudas and Florida to Brazil.	
*var. *olivacea.*	Florida to Cape Cod.	Shallow water.
**Holmesii* Lym., '60.		S. Carolina.
cinerea Lym., '65.		0–115 fath.
	Florida to Abrolhos Reefs, Brazil.	
pallida Verrill, 1899*a*, p. 7, pl. II, fig. 3.		110–200 fath.
rubicunda Lym., '65.	Littoral.	Shallow water.
squamosissima Lym., '65.	Littoral ?.	Shallow water.

appressa Say, '25. 0–20 fath.
Bermudas and Florida to Bahia, Brazil.
elaps Lym., '65. Nar. Blake Exped., p. 111, fig. 394.
120–300 fath.

Ophiopeza Peters, 1851.

Yoldii Ltk., '56. Shallow water.
Petersi Lym., '78. 8–177 fath.

Pectinura Forbes, 1842.

angulata Lym., '83. 88–248 fath.
tessellata Lym., '83. 451 fath.
lacertosa Lym., '83. 159 fath.

Ophiopæpale Ljng., 1871.

Goesiana Ljn., '71. Lym., in A. Ag., Nar. Blake Exped., p. 111, fig. 393. 38–250 fath.

Family, **OPHIOLEPIDIDÆ** Ljung., 1867.

Ophiolepis M. and Tr., 1840.

paucispina Müll. and Tr., '42. 3–4 fath.
Florida and West Indies to Rio de Janeiro.
**elegans* Ltk., '59. Charleston, S. C.; West Indies. 8½–30 fath.

Ophiozona Lym., 1865.

impressa Lym., '65. 69–300 fath.
nivea Lym., '75; Nar. Blake Exped., p. 110, fig. 390.
50–424 fath.
var. *compta* Verrill, 1899*a*, p. 9, pl. III, fig. 2.
This Vol., p. 303, pl. XLIII, figs. 1, 1*a*. 110–200 fath.
insularia Lym., '78. 310–315 fath.
marmorea Lym., '83. 114–250 fath.
clypeata Lym., '83. 88–157 fath.
tessellata Lym., '78. 60–300 fath.
Antillarum Lym., '78. 94–508 fath.
dubia Lym., '78. 539 fath.

Ophioceramis Lym., 1865.

Januarii Lym., '65. 35–100 fath.
West Indies to Rio de Janeiro, Brazil, and Patagonia.
albida Lym., '75. 19–100 fath.
West Indies to Rio La Plata.

Ophiothyreus Ljng., 1871.

Goësi Ljn., '71. 80–300 fath.

Ophiernus Lym., 1878.

adspersus Lym., '83. 159–1030 fath.
Gulf of Bengal and off the Malabar Coast, 490–1997 fath. (Kœhler).

Ophioglypha Lym., 1860.

fasciculata Lym., '83. 288 fath.

abyssorum Lym., '83. 1097 fath.

scutata Lym., '83. 95 fath.

tenera Lym., '83. 124 fath.

acervata Lym., '69. 60–350 fath.

falcifera Lym., '69. 200–576 fath.

**lepida* Lym., West Ind., 425–1242 fath. East Atlantic, 425–900 fath. Off East Coast U. S., 813–2574 fath.

Ljungmani Lym. Off Bahia, 350 fath.

variabilis (?) Lym. (*Var.?*) 175–955 fath.

? irrorata Lym., '78; '83. 1058–1097 fath. Type, Cape Good Hope, 1900 fath.; Australia, 410 fath.

? convexa Lym., '78; '83. 114–270 fath. Type, Pacific, 2050–2300 fath.; W. Africa, 2350 fath.

Ophiocten Lutk., '54.

depressum Lym., '79. 315 fath.

Ophiomusium Lym., '69.

eburneum Lym., '69. 92–500 fath.

var. *elegans* Verrill, 1899*a*, p. 12, pl. III, figs. 1, 1*a*. 110–260 fath.

**Lymani* Wy. Thom., '73. North Atlantic, 238–2369 fath. Off coast of Europe; off East Coast U. States, south to S. Carolina, common ; off Tristan d' Acunha, 1100 fath.; Pacific, 565–1825 fath.

serratum Lym., '78. 124–1097 fath.

cancellatum Lym., '78 (? var.). Bermuda, 435 fath.

Perhaps the same as the next. Mr. Lyman's type was from off Japan.

stellatum Verrill, 1899*a*, p. 14, pl. I, figs. 3, 3*a*. 110–260 fath.

planum Lym., '78 ; Nar. Blake Exped., p. 112, fig. 396. Mediterranean, 4020 meters; Gulf of Bengal, 1520–1987 fath. (Kœhler). W. Indies, 300–955 fath.

acuferum Lym., '75. 27–1030 fath.

archaster Wy. Thom., '73. Off Brazil, 1900 fath.

sculptum Verrill, 1899*a*, p. 106, pl. II, fig. 2, pl. VIII, fig. 2. 110–260 fath.

pulchellum Wy. Thom. 150–1675 fath. North of Cape Verde Is.; off Brazil; S. Atlantic.

validum Ljung., '71. 60–1568 fath. North of Laquedives, 931 fath. (Kœhler).

testudo Lym., '78. 69–508 fath.

Ophiolipus Lym.

Agassizii Lym., '78; Nar. Blake Exped., p. 115, fig. 401.
100–118 fath.

Ophiomastus Lym.

secundus Lym., '78; Nar. Blake Exped., p. 113, fig. 398.
60–1131 fath.

Ophiophyllum Lym.

?petilum Lym., '79; Nar. Blake Exped., p. 110, fig. 391.
Type, off Fiji Is., 600 fath. W. Indies, 542 fath.

Ophiopreyn Lym.

longispinus Lym., '78. 60–625 fath.

Ophioconis Lutk., 1869.

miliaria Lym., '78; Nar. Blake Exped., p. 112, fig. 395.
Ver. 1899a, p. 17. 163–450 fath.

Family, **OPHIOTHRICHIDÆ** Ljung. Ver., This Vol., p. 304.

Ophiothrix Müll. and Trosch.

**angulata* Ayres, '52. Ver., 1899*a*, p. 18 (descr.). 0–200 fath.
Chesapeake Bay and Bermudas to Rio de Janeiro.

Œrstedii Ltk., '56. Ver., 1899*a*, p. 20, colors. 0–13 fath.

lineata Lym., '60. 0–20 fath.

pallida Ljung., '71. 180 fath.

Suensonii Ltk., '56. Ver., 1899*a*, p. 21, colors. 0–262 fath.
Bermudas and Florida to Brazil, Lat. 22° S.

Family, **OPHIOCOMIDÆ** Ljung., 1867.

Ophiocoma L. Agassiz, '35.

echinata L. Agassiz, '35. 0–13 fath.
Bermudas and Florida to Brazil.

Riisei Lütken, '56, 0–210 fath.
Bermudas and Florida to Brazil.

pumila Ltk., '56. 0–100 fath.
Bermudas and Florida to Northern Brazil.

Ophiopsila Lutk.

Riisei Ltk., '59. 0–200 fath.
Bermudas and Florida to Northern Brazil.

Family, **AMPHIURIDÆ** Ljung., '67. Ver., This Vol., pp. 305-319.

Ophiactis Lutk.

Mülleri Ltk., '56. 1–337 fath.

Bermudas and Florida to Abrolhos Islands.

var. *quinqueradia* Lym. 27–338 fath.

dispar Verrill, 1899*a*, p. 31, pl. VIII, figs. 3–3*e*. 3–13 fath.

**Krebsii* Ltk., '56. 1–20 fath.

Bermudas and S. Carolina to Rio de Janeiro.

loricata Lym., '69. 10–110 fath.

Lymani Ljn., '71. 40 fath.

plana Lym., '69. 10–140 fath.

AMPHIURA Forbes. Ver., This Vol., pp. 306, 307 (rest.).

**Otteri* Ljung., '71. 175–1467 fath.

Off Portugal and off New England to West Indies.

Palmeri Lym., '82. 100 fath.

incisa Lym., '83. 583 fath.

semiermis Lym., '69. 377–539 fath.

flexuosa Ljung. Var. ?, Lym., '83. 262 fath.

Florida to Southern Brazil.

grandisquama Lym., '69. 10–262 fath.

lunaris Lym., '78. 424–955 fath.

Stimpsoni Ltk., '59. 10–69 fath.

West Indies to Cape Frio, Brazil.

The two following supposed "varities" of antarctic species are recorded by Lyman, but have not been described nor figured, from the West Indian fauna. They were, therefore, omitted from the analytical table (pp. 308–311).

angularis Lym., '78. Var.? 476 fath., Antarctic Ocean.

tomentosa Lym., '78. Var.? 464 fath., Antarctic Ocean.

AMPHIPHOLIS Ljung., '66. Ver., This Vol., pp. 306, 311.

**tenuispina* Ljng., '64; '67. 60–487 fath.

Off U. S. East Coast, C. Hatteras to Cape Cod ; North Europe to Iceland.

**tenera* (Ltk.) Ljng. 4–200 fath.

S. Carolina to Cape Frio, Brazil.

**gracillima* (Stimp.) Ljng., '67, '71. S. Carolina. West Ind. Brazil? (as *A. Januarii* Ljng.). Littoral.

**Goësi* Ljng., '71. 14–280 fath.

Bermuda and Cape Hatteras to Antilles.

abnormis (Lym., '78.) Ver. 101 fath.

AMPHIODIA Ver., 1899*a*, p. 25. This Vol., pp. 306, 312.

repens (Lym., '75) Ver. Florida, 14 fath.

pulchella (Lym., '69) Ver. Florida, 18–39 fath.

**atra* (Ltk., '59) Ver. S. Carolina. Littoral.

Riisei (Ltk., '60) Ver. Shallow water.

West Indies to Southern Brazil.

Lütkeni (Ljng., '71) Ver. 10 fath.

AMPHIOPLUS Ver., 1899*a*, p. 25, 1899. This Vol., pp. 306, 314.

tumida (Lym., '78) Ver. 94–321 fath.

nereis (Lym., '83) Ver. 148 fath.

Agassizii Ver. This Vol., p. 315. 116 fath.

cuneata (Lym., '78) Ver. 159–370 fath.

**duplicata* (Lym., '75) Ver. 73–1568 fath.

Mediterranean, 1385–2178 meters; off the Azores, 1300–1850 meters (Kœhler).

Stearnsii (Ives) Ver. Shallow.

Verrillii (Lym., '79) Ver. 424–2650 fath.

AMPHILIMNA Ver., 1899*a*, p. 30, 1899. This Vol., p. 318.

Caribea (Ljng., '71) West Indies, 300–400 fath.

Perhaps identical with the next.

**olivacea* (Lym.) Ver., This Vol., p. 318, pl. XLII, figs. 1, 1*a*. West Indies, 40–126 fath.

West Indies, northward to N. England, in 63–266 fath., beneath the Gulf Stream.

OPHIOCNIDA Lym. Ver., This Vol., p. 315 (restr.).

scabriuscula Lym., '65.

Florida to Bahia, Brazil. Littoral.

filogranea Lym., '75. Shallow.

HEMIPHOLIS Lym.

**cordifera* Lym., '65. Littoral. Shallow water. N. Carolina to Brazil.

OPHIOPHRAGMUS Lym.

* *Wurdemani* Lym., '65.

Beaufort, N. C. to West Indies. Littoral. Shallow water.

septus (Lutk., '59) Lym., '65. 47 fath.

AMPHILEPIS Ljung., '67.

patens Lym., '79. 2160 fath.

OPHIONEMA Lutk., '69.

intricata Ltk., '69. 180 fath.

OPHIONEPHTHYS Lutk., '69.

limicola Ltk., '69. Littoral? Shallow water.

OPHIONEREIS Lutk., '59.

reticulata Lutken, '59. 0–94 fath.

Bermudas and Florida to Rio de Janeiro, Brazil.

OPHIOPLAX Lym.

Ljungmani Lym., '75. 80–250 fath.

OPHIOSTIGMA Lutk., '56.

isacanthum (Say) Lym., '65. 0–122 fath.

Ophiochytra Lym.

tenuis Lym., '83. 291–383 fath.

Family, **OPHIACANTHIDÆ** Verrill, 1899*a*, p. 34. This Vol., p. 319.

Ophiacantha Müll. and Trosch., '42. Ver., This Vol., pp. 320–340 (restr.)

vepratica Lym., '78. 291–600 fath.

aspera Lym., '78. 73–400 fath.

stellata Lym., '75. 56–262 fath.

pentacrinus Ltk., '69. 74–625 fath.

segesta Lym., '78. 1075 fath.

cosmica Lym., '78. 350–2225 fath.

(*Ophientodia*) *scutata* Lym., '78. Ver., This Vol., p. 341, (descr.). 124–338 fath.

(*Ophientodia*) *pectinula* Ver., This Vol., p. 342 (descr.). Station 227, Blake Exped., 573 fath.

(*Ophioscalus*) *echinulatus* Lym., '78. 205–955 fath.

Ophialcæa Ver., 1899*a*, p. 42. This Vol., pp. 326, 331.

Nuttingii Verrill, 1899*a*, p. 46, pl. I, fig. 2; pl. VIII, figs. 1, 1*a*. 200 fath.

Ophiacanthella Ver., 1899*a*, p. 39. This Vol., pp. 326, 344.

Troscheli (Lym., '78) Ver. 73–300 fath.

Ophiomitrella Ver., 1899*a*, p. 43. This Vol., pp. 336, 352.

lævipellis (Lym., '83) Ver. This Vol., p. 343 (descr.). 88–124 fath.

Ophiolimna Ver., 1899*a*, p. 44. This Vol., p. 345.

mixta (Lym., '78) Ver. This Vol., p. 346. 160–576 fath.

Ophiopora Ver., 1899*a*, p. 43. This Vol., p. 345.

Bartletti (Lym., '83) Ver. This Vol., p. 345.

Ophiopristis Ver., 1899*a*, p. 47. This Vol., p. 347.

hirsuta (Lym., '75) Ver. 82–955 fath.

ensifera Ver., 1899*a*, p. 47, pl. IV, figs. 1–1*d*. This Vol., pl. XLIII, fig. 4. 110–160 fath.

cervicornis (Lym., '83) Ver. 208–573 fath.

Ophiotreta Ver., 1899*a*, p. 40. This Vol., pp. 333, 347.

lineolata (Lym., '83) Ver., 1899*a*, p. 51. 110–208 fath.

sertata (Lym., '69) Ver., 1899*a*, p. 54. This Vol., p. 348. 123–411 fath.

Amphipsila Ver., 1899*a*, p. 55. This Vol., pp. 333, 348.

maculata Ver., 1899*a*, p. 55, pl. III, figs. 4, 4*a*. This Vol., p. 348; pl. XLIII, figs. 5, 5*a*. 200 fath.

fulva (Lym., '78). 13–175 fath.

Ophiomitra Lym., Ver. This Vol., pp. 349, 350; restr.
valida Lym., '69. Ver., This Vol., p. 353 descr.
10–1105 fath.
ornata Ver., 1899*a*, p. 58, pl. v, figs. 1, 1*a*. This Vol., p. 350, pl. xliii, fig. 3. 100–260 fath.
Ophioplintiiaca Ver. This Vol., p. 351.
dipsacos (Lym., '78) Ver. This Vol., p. 351. 390 fath.
incisa (Lym., '83) Ver. This Vol., p. 351. 334–508 fath.
chelys (Lym., '78) Ver., This Vol., p. 352. 1124–1530 fath.
Ophiocamax Lym., Ver. This Vol., p. 354.
hystrix Lym., '78 ; Nar. Blake Exped., p. 110, fig. 392. Ver., This Vol., p. 395. 114–300 fath.
austera Verrill, 1899*a*, p. 60, pl. vi, figs. 1, 1*a*; pl. vii, fig. 2. This Vol., p. 355, pl. xliii, fig. 2. 110–200 fath.
fasciculata Lym., '83. Ver. This Vol., p. 355. 180–250 fath.
Off Andaman Islands, 130–250 fath. (Kœhler).
Ophiothamnus Lym., '69.
vicarius Lym., '69. 15–611 fath.
exiguus (Lym., '78) Ver. This Vol., p. 353. 84–400 fath.
Ophiolebes Lym., '78.
humilis Lym., '69. 125–324 fath.
claviger (Ljng.) Lym. (Var. ?), '83. 524 fath.
Ophioblenna Lutk.
Antillensis Ltk., '59. W. Indies. Shallow water.
Ophiotoma Lym.
coriacea Lym., '83. 1242 fath.

Subfamily, **OPHIOCHONDRINÆ** Ver., This Vol., p. 355.

Ophiochondrus Lym., '69. Ver., This Vol., p. 356 (restr.).
convolutus Lym., '69. 80–400 fath.
crassispinus Lym., '83. This Vol., p. 356. 229 fath.
gracilis Ver., 1899*a*, p. 64. 100–260 fath.
Ophiochondrella Ver., This Vol., p. 355.
squamosus (Lym) Ver. This Vol., p. 355. 88–250 fath.

Family, **OPHIOSCOLICIDÆ** Ver.

(See This Vol., p. 357.)

Ophioscolex Müll. and Trosch., 1842.
**purpureus* Dub. and Koren., '44 (var. ?)
West Indies, 110 fath.
Northern Europe to Norway, 64–767 fath.
fragilis Ver., '99. This Vol., p. 358. 82 fath.
tropicus Lym., '78. 390 fath.

Ophiosciasma Lym., '78.

granulata Lym., '83. 96–100 fath.

Astrogeron Ver., This Vol., p. 359.

supinus (Lym.) Ver. 200–464 fath.

Ophiobyrsella Ver., This Vol., p. 358.

serpens (Lym.) Ver. This Vol., p. 358. 69 fath.

Ophiobyrsa Lym.

Perrieri Lym., '83. 288 fath.

Family, **OPHIOMYCETIDÆ** Verrill, This Vol., p. 359.

Subfamily, **OPHIOMYCETINÆ** Ver., This Vol., p. 360 (descr.).

Ophiomyces Lym., '80.

mirabilis Lym., '68. 237–422 fath.

frutectosus Lym., '69; Nar. Blake Exped., p. 111, fig. 397. 77–288 fath.

Family, **OPHIOHELIDÆ** Ver., This Vol., p. 361.

Ophiohelus Lym., '80.

umbella Lym., '80; Nar. Blake Exped., p. 116, figs. 202, 203. Barbadoes, 82 fath.

Family, **OPHIOMYXIDÆ** Ljng.; Ver., 1899*a*, p. 65; This Vol., p. 361.

Ophiomyxa Müll. and Trosch., '42.

flaccida Ltk., '59. Ver., 1899*a*, p. 65, colors. 0–175 fath. Bermudas and Florida to Bahia and the Abrolhos Reefs, Brazil.

tumida Lym., '83, Ver., 1899*a*, p. 67, pl. III, fig. 5; This Vol., pl. XLII, figs. 3, 3*a*, 3*b*. 13–300 fath.

brevicauda Ver., 1899*a*, p. 66, pl. III, fig. 3; This Vol., pl. XLII, figs. 4–4*d*. 110–200 fath.

Ophiodera Ver., 1899*a*, pp. 65, 67. This Vol., p. 362.

Stimpsoni (Lym., '75) Ver., 1899*a*, p. 67, pl. II, figs. 4, 4*a*; This Vol., p. 362, pl. XLII, figs. 2–2*c*. 60–240 fath.

Family, **HEMIEURYALIDÆ** Ver., 1899*a*, p. 70; This Vol., p. 363.

Hemieuryale Von Mart., '67.

pustulata Von Mart., '67. Ver., This Vol., p. 363. 74–180 fath.

Ophioplus Ver., 1899*a*, p. 70; This Vol., p. 365.

tuberculosus (Lym.) Ver., 1899*a*, p. 71, pl. I, figs. 1–1*b*; This Vol., p. 365, pl. XLIII, figs. 6–6*d*. 96–200 fath.

Sigsbeia Lym., '78.

murrhina Lym., '78; Nar. Blake Exped., p. 114, fig. 399. Ver., 1899*a*, p. 72, pl. II, figs. 1, 1*a*, (young, descr.); This Vol., p. 365, pl. XLII, fig. 7. 88–422 fath.
Young, 3–200 fath.

Family, **OPHIOBRACIONTIDÆ** Ver., This Vol., p. 366.

Ophiobrachion Lym., '83.

uncinatus Lym., '83. Off Cuba, 250 fath.

Order II.—**EURYALÆ** Müll. and Trosch., 1842.

(See This Vol., p. 366.)

Family, **GORGONOCEPHALIDÆ** Ver., 1899*a*, p. 83 (restr.); This Vol., p. 367.

Astrophyton L. Agassiz, '35.

**muricatum* Ag. (*costosum* Lym.) Ver., 1899*a*, p. 84 (descr.) Charleston, S. C., Ives, 1889, p. 178. 1–13 fath.

Krebsii Œrst. and Ltk., '56. 50–125 fath.

Cæcilia Ltk., '56; Blake Exped. Narrative, i, p. 310, fig. 388. 3–124 fath.

Gorgonocephalus Leach, 1815.

**aborescens* Agassiz, '39. W. Indies? Mediterranean.

cacaoticus Lym., '74. 20 fath.

mucronatus Lym., '69. Ver., 1899*a*, p. 85 (descr.) 80–288 fath.

Family, **ASTROCHELIDÆ** Ver., 1899*a*, p. 79; This Vol., p. 369.

Astrocnida Lym., '72.

isidis Lym., '72; Nar. Blake Exped., p. 115, fig. 400. Ver., 1899*a*, p. 83. 56–120 fath.

Astrogomphus Lym., '69.

vallatus Lym., '69. Ver., 1899*a*, p. 80 (descr.). 80–337 fath.

rudis Ver., 1899*a*, p. 82, pl. VII, figs. 1, 1*a* (descr.). 116–200 fath.

Astroporpa Œrsted and Lutk., '56.

**annulata* Œrst. and Ltk., '56. 20–163 fath.
Off Cape Hatteras and Chesapeake Bay, 48–167 fath.

affinis Ltk., '59. 50 fath.

Family, **ASTROSCHEMIDÆ** Ver., 1899*a*, p. 76; This Vol., p. 370.

Astroschema Œrsted and Lutk., '56.

oligactes Ltk., '56. 69–288 fath.

arenosum Lym., '78. 124–805 fath.

tenue Lym., '75. 88–124 fath.

brachiatum Lym., '79. 270–435 fath.

lævе Lym., '75. 56–262 fath.

sulcatum Ljn., '71. 200–320 fath.

intectum Lym., '78. 175–200 fath.

Nuttingii Ver., 1899*a*, p. 77, pl. VII, figs. 3, 3*a*. 105–125 fath.

Ophiocreas Lym., '69.

lumbricus Lym., '69. 60–580 fath.

spinulosus Lym., '83; Nar. Blake Exped., p. 110, fig. 389. 116–288 fath.

œdipus Lym., '79 (Var. ?). 580 fath.

Family, **ASTRONYCIDÆ** Ver., 1899*a*, p. 74; This Vol., p. 370.

Astronyx Müll. and Trosch., '42.

Lymani Verrill, 1899*a*, p. 74 (descr.), pl. VIII, figs. 4–4*e*; This Vol., p. 371 (descr.), pl. XLII, figs. 6–6*c*. 200–980 fath.

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EXPLANATION OF THE PLATES.

Plate XLII.

Figure 1—*Amphilimna olivacea* (Lym.) Ver., p. 318. Under side of a part of the disk and the proximal part of an arm. ×7.

Figure 1*a*—The same. A row of spines from the middle of an arm. ×18.

Figure 2—*Ophiodera Stimpsoni* (Lym.) Ver., p. 362. Under side of a part of the disk and of a ray. ×7.

Figure 2*a*—The same. A row of spines. ×28.

Figure 2*b*—The same. Under side of the distal part of an arm. ×7.

Figure 2*c*—The same. One of the teeth. ×18.

Figure 3—*Ophiomyxa tumida* Lym., p. 380. Under side of a part of the disk and of an arm. ×7.

Figure 3*a*—The same. A row of spines from the middle of an arm. ×12.

Figure 4—*Ophiomyxa brevicauda* Ver., p. 380. Under side of a part of the disk and of an arm. ×5.

Figure 4*a*—The same. One of the teeth. ×28.

Figure 5—Undetermined Ophiuran (Young?). Nearly vertical view of two joints from the middle of an arm. ×28.

Figure 5*a*—The same specimen. Side view of two joints from the distal parts of an arm. ×28.

Figure 6—*Astronyx Lymani* Ver., p. 377. Type. Under side of a part of the disk and of an arm. ×7.

Figure 6*a*—The same specimen. Side view of three joints from the middle part of an arm. ×9.

Figure 6*b*—The same. Hook-shaped spines, more enlarged.

Figure 6*c*—The same. Hooks from the distal part of an arm.

Figure 7—*Sigsbeia murrhina* Lym. Young, p. 365. Under side of a part of the disk and of two arms. ×6.

Plate XLIII.

Figure 1—*Ophiozona nivea* Lym., var. *compta* Ver., p. 303. Type. Upper side of the disk and bases of the arms. ×4.

Figure 1*a*—The same specimen (297, Blake Exped.). Under side of the disk. ×3½.

Figure 2—*Ophiocamax austera* Ver., p. 355. Type. Under side of a part of the disk and of an arm; *m*, madreporic plate. ×5.

Figure 3—*Ophiomitra ornata* Ver., p. 350. Type. Under side of a part of the disk and of an arm; *m*, madreporic plate. ×5.

Figure 4—*Ophiopristis ensifera* Ver., p. 347. Type. Under side of a part of the disk and of an arm. ×6.

Figure 5—*Amphipsila maculata* Ver., p. 348. Under side of a part of the disk and base of an arm. ×7.

Figure 5*a*—The same. A row of spines from the middle of an arm. ×14.

Figure 6—*Ophioplus tuberculosus* Ver., p. 365. Dorsal side. ×5.

Figure 6*a*—The same. Under side. ×7.

Figure 6*b*—The same. Profile view of a part of the disk and coiled arms. ×7.

Figure 6*c*—The same. Side view of a part of the middle of an arm. ×5.

Figure 6*d*—The same. Dorsal view of a more distal part of an arm. ×5.

VIII.—The Hawaiian Hepaticæ of the Tribe Jubuloideæ.—By Alexander W. Evans.

A few Hepaticæ from the Hawaiian Islands were collected by Menzies in 1793. They consist of small specimens and of fragments picked from other plants and are for the most part in the herbarium of Sir William J. Hooker, now preserved in the collections of the Royal Gardens at Kew. In the early decades of the present century additional small collections were made by Beechey, by Gaudichaud, and by Meyen, during their voyages of exploration, and these, together with the Menzies plants, are the Hawaiian Hepaticæ referred to in the Synopsis Hepaticarum of 1844-47. Scarcely thirty species, most of them from the island of Hawaii, are mentioned in this volume, which gives us, therefore, little idea of the richness of the hepatic flora of the Islands.

About thirty years ago another small collection was made by the late Dr. William Hillebrand. His attention, of course, being chiefly devoted to the phanerogams and pteridophytes, to the knowledge of which he made important and well known contributions, the Hepaticæ which he gathered were somewhat fragmentary in character and consisted mainly of large and conspicuous species, to which occasionally smaller forms remained attached. The collection, nevertheless, included a number of undescribed plants. Some of the specimens were sent for determination to Mr. C. F. Austin and others to Mr. William Mitten, and, as these two writers worked independently of each other, certain of the new species received two names apiece. The published accounts of Hillebrand's plants appeared between 1869 and 1876. In 1872, the Swedish botanist, Dr. Johan Ångström, published a list of the Hawaiian Hepaticæ collected twenty years previously by Professor N. J. Andersson, during the voyage around the world of the frigate *Eugenie;* and, in 1874, Austin published a list of the species collected by Messrs. Mann and Brigham in 1872. In both of these lists new species are described and the synonymy is complicated by giving new names to certain previously described species. Most of the plants in these three collections came from the island of Oahu.

The first thorough and systematic collection, however, was the one made in 1875 and 1876 by Mr. D. D. Baldwin, nearly all of whose specimens came from the island of Maui. Mr. Baldwin sent

his plants to Professor D. C. Eaton, who forwarded sample-specimens of them to Mr. Austin for determination. Austin described several of the new species from this collection in 1879 and left several others in manuscript. In 1892, the present writer compiled a provisional list of the species from the Islands, based upon Baldwin's collection and depending largely on the determinations made by Austin.

In 1896 Herr Stephani described two of Gottsche's manuscript species from specimens collected by Didrichsen, and in the following year, published a revised list of the Hawaiian Hepaticæ, adding several new species from the collections made by Mr. A. A. Heller in 1895, and several others from specimens in the herbaria of Drs. Askenasy and Spruce. He also ascribed the various Lejeuneeæ to their respective genera, as these are at present understood.

During the summers of 1897, '98 and '99, large and important collections were made by Mr. C. M. Cooke, Jr., mainly on the islands of Oahu and Kauai. These collections have brought to light several new and interesting species and have added much to our knowledge regarding the distribution of forms previously known. Mr. Cooke's specimens have furnished the material for most of the descriptions and illustrations in the present paper.

Even now, however, our knowledge of the Hawaiian hepatics is doubtless far from complete: the collections of recent years have been made almost entirely on the islands of Oahu, Maui and Kauai, and we know little more about the species growing on the large island of Hawaii than was known fifty years ago. From the island of Molokai also, which seems favorable for these plants, only three species have been reported. It is quite possible that a systematic collection on Hawaii and a careful search on the other islands, particularly for the minuter forms, would more than double the number of species which we now know.

The present paper includes a part only of the leafy Hepaticæ, the Jubuloideæ of Schiffner. In its preparation, I have been able, through the kindness of correspondents and the curators of herbaria, to examine the original specimens of nearly all of the Hawaiian species. Those who have given me the most assistance and to whom I would express my grateful acknowledgments, are the following: Mr. W. H. Pearson, Professor A. G. Nathorst, Mr. William Mitten, Herr F. Stephani, Professor Victor Schiffner, Mr. W. B. Hemsley, Dr. P. Hennings, Professor L. M. Underwood and Mr. A. Gepp.

The tribe Jubuloideæ, as defined by Schiffner,* is the equivalent of the subtribe Jubuleæ of the Synopsis Hepaticarum† and of the tribe Jubuleæ of Spruce.‡ It is without doubt the most natural assemblage of forms among the leafy Hepaticæ; it is in fact so natural that Spruce did not hesitate to place it in contrast to his tribe Jungermannieæ, which included all the remaining acrogynous Jungermanniaceæ and the anacrogynous Jungermanniaceæ or Metzgeriaceæ§ as well. Schiffner, on the other hand, looks upon the group as one of the minor divisions under the acrogynous Jungermanniaceæ, equal in systematic value to the Ptilidioideæ, the Scapanioideæ, or any of the other five tribes which he recognizes. The morphological papers of Leitgeb‖ would, of course, prevent a wide acceptance of Spruce's view, and the disposition made by Schiffner is more in accordance with the views of most recent hepaticologists and apparently with the facts. A reason for the unusual division advocated by Spruce is perhaps to be found in the extraordinary development of the Jubuloideæ in the tropics. Among the Hepaticæ of equatorial South America, to whose collection and study Spruce devoted many years of his life, more than half of the species which he found belonged to this group; in the Hawaiian Islands, only about a quarter of the known species are Jubuloideæ, but it is probable that the higher proportion will be reached both here and in other tropical countries, when their hepatic floras shall have been more thoroughly investigated.

Although so natural for a hepatic group, the characters of the Jubuloideæ, particularly those drawn from the gametophyte, are somewhat difficult to define. This is partly because the sexual plant exhibits considerable variation within the group, and partly because several of its most striking and constant peculiarities recur in other genera, sometimes widely removed from the Jubuloideæ. In the first place the gametophyte is very variable in size; from the smaller species of *Cololejeunea*, which are often only a few millimeters long, we may pass by all gradations to the larger *Frullaniæ*, some of which form drooping tufts a half meter in length. The more essential characters drawn from the vegetative organs are likewise just as variable, although they show certain peculiarities which are fairly

* Engler & Prantl, Natürl. Pflanzenfam. i^3, 116. 1893.

† L. c. 283. 1845.

‡ Hep. Amaz. et And. in Trans. & Proc. Bot. Soc. Edin. xv. 1. 1885.

§ Underwood, Bot. Gazette, xix, 356. 1894.

‖ Untersuch. über die Lebermoose, 1874-1881.

constant throughout the group. The leaves are complicate-bilobed,* the antical lobes being the larger and incubous in their arrangement, while the smaller postical lobes or "lobules" are usually wholly or partially inflated and serve as water-sacs. Except in the two genera *Cololejeunea* and *Metzgeriopsis*, underleaves are always present; usually there is only one underleaf developed for each pair of side-leaves, but in the genera *Diplasiolejeunea* and *Colurolejeunea* there is an underleaf for every side-leaf, a peculiarity found nowhere else among the Hepaticæ. The branches, sexual as well as vegetative, are invariably lateral. The female inflorescence, which is of course always terminal, is sometimes borne on the main stem or on a principal branch, sometimes on a short, special branch. The number of archegonia is always small, almost never exceeding four. The perichætial bracts, like the leaves, are complicate-bilobed, but they are usually larger and their lobules† are never inflated; the bracteoles‡ likewise are larger than ordinary underleaves. A perianth is always present and is entirely free from the bracts; it is of the hypogonianthous type, but its keels are not always distinct; in the upper part, it is abruptly contracted into a more or less distinct beak with a small opening, and it becomes lacerated when the capsule is extruded. The calyptra is free. The antheridia are borne, usually in pairs, in the axils of inflated, complicate-bilobed, perigonial bracts, whose lobes are subequal in size; these bracts are imbricated, often very densely so, and occur in clusters of from two to many pairs, sometimes in the course of an ordinary branch, sometimes on a short specialized branch. The corresponding bracteoles are usually smaller than ordinary underleaves and are often absent from the upper part or even from the whole extent of the antheridial spike. The rhizoids of the Jubuloideæ are sometimes abundant and sometimes very scanty. They are borne in clusters, each cluster arising from the lower surface of an underleaf, close to the base. In the genus *Cololejeunea*, the clusters of rhizoids are found on the postical surface of the axis, in the position where underleaves would naturally be expected.

The sporophyte, although so much simpler than the gametophyte, affords important and constant characters. The stalk, instead of

* A single exception is found in the monotypic genus *Myriocolea* Spruce, of South America, in which no lobule is developed.

† In certain genera the lobules are small and indistinct and are sometimes entirely obsolete.

‡ The bracteoles are absent in the genera without underleaves; they seem to be absent also in most species of *Colurolejeunea*.

being of the same diameter throughout, as in most hepatics, broadens out above into a disc of the same color as the capsule-wall and several cells thick in the middle part.* On the circumference of this disc the four valves of the capsule are inserted, and it appears, therefore, as if the capsule were not split to the base. The valves themselves are usually two cells thick and each bears on its inner surface close to the apex a cluster of truncate unispiral elaters. The cells of the valves do not show the peculiar band-like thickenings usually found in the cells of the inner layer of the capsule-wall, but are merely irregularly thickened.

The Jubuloideæ fall naturally into two well-marked subtribes: the Frullanieæ and the Lejeuneeæ.

The Frullanieæ are almost never of a bright green color but are tinged with brown or red, sometimes so deeply so as to be nearly black. The leaf-lobes are ovate to orbicular in shape, more or less convex, and usually with entire margins. The lobules are in the form of inflated hood-shaped or club-shaped sacs, attached to the postical margin of the lobe close to the base. The opening of the sac is usually near the point of attachment and is directed backwards; in a few species, however, the lobule is reflexed and the opening is consequently directed forwards. Sometimes only a part of the lobule is inflated, and sometimes, particularly in moist localities, the lobule appears as a narrow lanceolate lamina and is not inflated at all. A third part of the leaf, the stylus, is usually distinct in this subtribe; it is situated on the inner side of the lobule and is inserted, partly at least, on the stem. The stylus is usually in the form of a minute, subulate process, and may be looked upon as a part of the postical lobe, or as an appendage to it. Underleaves are always present and are almost invariably bifid.

A branch in the Frullanieæ develops from the whole of the postical half of a segment† and replaces the lobule of the leaf beneath whose lobe it is situated.‡ Corresponding with this method of branching, the first leaf of a branch is an underleaf; the second, a side-leaf turned toward the apex of the main axis; the third, a side-

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* Cf. Spruce, Hep. Amaz. et And. 5. 1885.

† This type of branching is found in many genera of Hepaticæ; it is particularly clear in *Porella*, *Lepidozia*, and others with incubous leaves, but is to be made out also in various genera with succubous leaves.

‡ An exception to this rule is found in the innovations and sometimes in the antheridial branches of *Jubula*, which conform to the type of branching described for the next subtribe.

leaf turned away from the apex; the fourth, a second underleaf, and so on.

The Lejeuneeæ are pale or bright green in color and are sometimes tinged with brown or black, but never with red. The leaf-lobes vary from orbicular to lanceolate in shape, and their margins show all gradations from entire to laciniate-dentate. With rare exceptions, the lobule is attached to the lobe by a broad fold and to the axis by a long, almost longitudinal line of insertion. The lobule is strongly convex when seen from the postical surface, and its free margin is either involute or appressed to the stem, so as to form with the lobe a fairly tight water-sac. In moist situations this becomes unnecessary, and the lobule is usually more or less reduced, sometimes so much so as to be hardly distinguishable. Underleaves, when present, are sometimes undivided and sometimes bifid.

A branch in the Lejeuneeæ springs from the basiscopic part of the postical half of a segment,* and the lobule of the corresponding leaf is normally developed. The branch remains close to this leaf and is apparently borne just behind it.† Corresponding with this method of branching, the first leaf of a branch is an underleaf; the second, a side-leaf turned away from the apex of the main axis; the third, a side-leaf turned toward the apex, and so on. According to Leitgeb, the first three leaves of a branch do not appear as such, but remain united as a sheath, enclosing the apical region of the branch, which may or may not develop farther.

A peculiar type of branch is the "innovation," which is found in nearly every genus of the Lejeuneeæ. These innovations are borne just behind one or both of the perichætial bracts, which are here reduced to a single pair. Sometimes an innovation is small and simple, but it is more frequently as large as the axis bearing it, whose own growth has been stopped by the formation of the archegonium. In such a case, the innovation itself, while still short, often gives rise to a second flower and a new innovation. This mode of growth is sometimes repeated several times, the result being a complicated and characteristic flower-cluster. In case an innovation is developed behind only one of the bracts, it is not unusual to have the bracts and perianth pushed to one side, where they seem to assume a lateral position, the innovation apparently

* An exception is found in the genus *Stictolejeunea*, where the branches are borne as in the Frullanieæ. Cf. Spruce, Hep. Amaz. et And. 307.

† This type of branching is found also in the genera *Radula* and *Scapania*. Cf. Leitgeb, Unters. über die Leberm. ii, 29.

being a continuation of the main axis. This condition may be readily distinguished from that in which a flower is really borne on a short lateral branch by the order of the leaves on the apparent axis beyond the flower: in case this is the true axis, the first leaf will be on the side next the flower; in case it is an innovation, the first leaf will be on the side away from the flower. Very striking examples of each condition may be found in the genus *Cololejeunea*.

Subtribe I. FRULLANIEÆ.

The Frullanieæ include only two genera, *Frullania* and *Jubula*, of which only the most important characters will be enumerated here.

In *Frullania*, both antical and postical lobes are attached to the axis by very short, almost transverse lines of insertion, the attachment in the case of the postical lobe being limited to the base of the stylus. The leaf-lobe, beneath which a branch is situated, is similar to the others in position and is attached to the main axis rather than to the branch. The first underleaf of the branch seems to function as the lobule of this lobe, and their lines of insertion come very close together. This underleaf is similar to other underleaves,* but is often distorted in position; and sometimes one of its divisions, the one next the lobe, is inflated like an ordinary lobule. Between this underleaf and the lobe, we occasionally find a small leafy structure, now appearing as a minute, subulate process, now as a small, more or less rudimentary sac. According to Leitgeb† this interposed body is derived from the first postical segment of the branch, which normally gives rise to the underleaf alone; it may be looked upon, therefore, as a supplementary part of this underleaf. Properly speaking, innovations are never present in *Frullania;* that is, no branches are ever developed just behind the perichætial bracts. It is not unusual, however, to find branching a little farther back from the perianth, and such a branch, which arises in the usual way, may apparently continue the axis, as in the Lejeuneeæ. The stalk of the capsule is more complicated than in *Jubula* or the following subtribe, and is usually built up of four concentric layers of cells.

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* According to Spruce (Hep. Amaz. et And. 5), this underleaf is truly the modified lobule, a view which is also expressed by the writer in his own work on the North American *Frullaniæ* (Trans. Conn. Acad. x, 3). The explanation just given is that of Leitgeb (Untersuch. über die Lebermoose, ii, 22), and, being based on embryological studies, is probably more nearly correct. It must be acknowledged, however, that the interposed body (described in the text) somewhat obscures Leitgeb's explanation.

† Unters. über die Lebermoose, ii, 25. 1875.

In the genus *Jubula*, which is intermediate in some respects between *Frullania* and the Lejeuneeæ, the plants are distinctly green and are never tinged with red. The leaf-lobe is attached to the axis by a long oblique line of insertion, the lobule is distant from the axis and is therefore not attached to it at all, and the stylus, which is reduced to a single cell, becomes obsolete very early: it appears, therefore, as if no part of the leaf, except the lobe itself, were attached to the axis. The lobes are often dentate or ciliate. The lobe beneath which a branch is situated is more oblique than the others and is attached partly to the axis and partly to the branch. The first underleaf of a branch is usually a simple lanceolate lamina: it is much pushed out of position, being attached partly to the axis and partly to the branch, and its line of insertion does not meet that of the lobe, which is here obviously without a lobule. Innovations, like those of the Lejeuneeæ, are present; in typical cases, there are two innovations for each inflorescence, though it is not unusual to find only one of them developed. In *Jubula Hutchinsiæ*,* the male branches apparently arise in the same way as those of the following subtribe, being borne behind small but otherwise normal and lobulate leaves: this peculiarity, however, is not constant for the genus and is not found in the Hawaiian species. The stalk of the capsule is formed of only two concentric layers of cells, as in the Lejeuneeæ.

1. **FRULLANIA** Raddi.

In the last published list of Hawaiian Hepaticæ,† ten species of *Frullania* are enumerated. An eleventh species, *F. Oahuensis*, first collected by Meyen, is not included here. Although published in 1843, this species was omitted from the Synopsis Hepaticarum, perhaps through an oversight, and has not since appeared in hepaticological literature. Several of these eleven species cannot be maintained. Three of them, *F. arietina*, *F. Kunzei*, and *F. squarrosa*, are listed on incorrect determinations, and three of the others, *F. explicata*, *F. oceanica*, and *F. Helleri*, are synonyms. Ångström's *F. Sandvicensis*, on the other hand, is a mixed species and was based on two perfectly distinct plants. The six species which I have been able to distinguish fall naturally into three of Spruce's subgenera and may be identified as follows:

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* Cf. Leitgeb, Unters. über die Leberm. ii, 37. 1875.

† Stephani, Hepaticae sandvicenses. Bull. de l'Herb. Boissier, v, 842. 1897.

Key to the Species.

Lobule inflated in upper part only, the lower forming a more or less distinct, plane expansion ; perianth with two distinct postical keels; inflorescence autoicous.

F. (*Chonanthelia*) *Aongstroemii.*

Lobule inflated throughout, attached to the lobe by a very short, almost transverse keel.

Lobule galeate (about as broad as long); perianth with one or two postical keels ; inflorescence dioicous.

Perianth slightly roughened on the keels, otherwise smooth ; leaves not squarrose. *F.* (*Trachycolea*) *Oahuensis.*

Perianth distinctly tuberculate ; leaves more or less squarrose. *F.* (*Trachycolea*) *Sandvicensis.*

Lobule clavate (longer than broad); perianth with a single postical keel; inflorescence autoicous.

Lobule distant from axis and parallel; lobes sharp-pointed; underleaves contiguous or imbricated ; branches not microphyllous. *F.* (*Diastoloba*) *apiculata.*

Lobule close to axis and parallel ; lobes rounded at apex ; underleaves distant or contiguous but not imbricated (except near the end of a stem or branch); branches not microphyllous. *F.* (*Diastoloba*) *Meyeniana.*

Lobule distant from axis and widely spreading ; lobes blunt or apiculate at apex; underleaves imbricated; some of the branches microphyllous and of short, limited growth. *F.* (*Diastoloba*) *hypoleuca.*

I. Subgenus Chonanthelia Spruce.

1. **Frullania Aongstroemii** sp. nov.

Frullania Sandvicensis Ångstr. Öfversigt af Kongl. Vetensk. Akad. Förhand. xxix, Häft 4, 28. 1872 (in part).

Plate XLIV., figs. 1-11.

Autoicous : plants growing in wide depressed tufts, greenish, tinged with yellow or brown : stems irregularly pinnately branched : leaves imbricated, not squarrose, the lobe ovate, arching over the stem, but scarcely or not at all cordate at base, decurved at the rounded apex, entire, connected with the lobule by a long fold parallel with the stem; lobule galeate above, and forming a plane triangular expansion below ; hood extending to the middle of the

lobule or beyond, compressed at the mouth and inflated in upper and outer parts; stylus minute, subulate: underleaves contiguous or subimbricated, small for the subgenus, orbicular, plane or somewhat revolute on sides, scarcely or not at all auriculate at base, bifid about one third with subacute lobes and sinus, margins entire or sinuate-unidentate on the sides: leaf-cells rather thin-walled, but with conspicuous trigones and occasional intermediate thickenings: ♀ inflorescence borne on a principal branch; bracts in about three pairs, unequally bifid, the lobe ovate (or narrowly ovate on the innermost bracts), obtuse to subacute, entire or sinuate on the margins, lobule ovate or ovate-lanceolate, acute or acuminate, subentire but bearing a distinct lobe-like tooth or stylus on the inner edge near the base; bracteole shortly connate with bracts on one or both sides, ovate, bifid about one third with narrow, acute or acuminate lobes and narrow sinus, subentire or unidentate on sides; perianth about half exserted, obovate, gradually narrowed into a short, broad beak, strongly two-keeled postically and with a broad shallow furrow antically: ♂ bracts in two or three pairs, occupying a short subglobose spike below the perianth.

Stems 0.17^{mm} in diameter, lobes of leaves 1 x 0.8^{mm}, lobules 0.5 x 0.3^{mm}, underleaves 0.4 x 0.35^{mm}, leaf-cells at edge of lobe 14μ, in the middle, 15μ, and at the base, 20μ in diameter, bract I, lobe 1.85 x 0.85^{mm}, lobule 1.85 x 0.75^{mm}, bracteole 1.35 x 0.7^{mm}, bract II, lobe 1.45 x 0.75^{mm}, lobule 1.25 x 0.6^{mm}, bracteole II, 1.35 x 0.6^{mm}, perianth 2.5 x 1.2^{mm}.

On rocks and trees. Oahu: Nuuanu (Heller); Luakaha (Cooke).

Frullania Aongstroemii, in most of the specimens at my disposal, grows in company with what I have called *F. Sandvicensis;* and it is quite evident that Ångström's original *Frullania Sandvicensis*, as described by its author, is a mixture of these two species. His sterile type-material, kindly sent me by Professor Nathorst, agrees closely with his description (so far as leaves and underleaves are concerned), and it agrees also with the numerous specimens of the emended *F. Sandvicensis*, which I have been able to examine. In his description of the perianth, however, he states:—"perianthium obovatum dorso subconcavum canaliculatum sæpe læviter bicarinatum, ventre bicarinatum," showing clearly that he did not have the perianth of a *Trachycolea* before him, but that of a *Chonanthelia*. The lower bracteoles, moreover, are described as bipartite, which certainly does not apply to the bracteoles of *F. Sandvicensis*, although it is not quite accurate for those of *F. Aongstroemii*. The

two species, although belonging to different subgenera, bear a certain superficial resemblance to each other. In certain cases the resemblance is still more marked from the fact that the lobule of *F. Aongstroemii* is sometimes inflated throughout nearly its whole extent, losing thereby its characteristic *Chonanthelia*-form, and closely approaching the lobule of *F. Sandvicensis*. These facts, together with the great rarity of the perianths in *F. Sandvicensis*, might easily account for the two having been confused. Even without their very characteristic perianths, however, there are good points of distinction between the species. The strongly cordate base of the lobe in *F. Sandvicensis*, the broad, emarginate and cordate underleaves, and the very conspicuous thickenings of the leaf-cells are quite unlike what we find in *F. Aongstroemii*.

In *Frullania arietina* Tayl., of tropical and subtropical America, *F. Aongstroemii* finds a close ally. It differs from this species in its autoicous, not paroicous inflorescence, in the entire margins of its bracts, which are less highly connate with the bracteoles, and in the different shape of its lobules. It will be remembered that Austin* has already reported *F. arietina* from the Hawaiian Islands as growing with his *Dendroceros Clintoni*. Mixed with the specimens of this last species from Mr. Pearson's collection, I find a few sterile stems of *F. Sandvicensis* but no other *Frullania*, so that it is probable that Austin's determination was incorrect. Another species of tropical America, *F. gibbosa* Nees, resembles *F. Aongstroemii* in its autoicous inflorescence and entire bracts, but it differs in its squarrose, densely imbricated leaves, with much larger lobule and large disc-like stylus, in its broader underleaves, cordate at the base and less deeply bifid at the apex, and in its more pointed perianths.

II. Subgenus Trachycolea Spruce.

2. **Frullania Oahuensis** Hampe.

Frullania Oahuensis Hampe; G. L. & N. Nova Acta Acad. Leop.-Car. xix, suppl. 1, 471. 1843.

Plate XLIV., figs. 12-19.

Dioicous: plants closely appressed to substratum, scattered or forming loose thin mats, reddish- or brownish-green, sometimes almost black: stems irregularly pinnately branched: leaves imbricated, the lobe ovate, somewhat convex, arching over the stem and slightly cordate at base, rounded at the apex, entire; lobule galeate,

* Bull. Torr. Bot. Club, v, 15. 1874.

more or less distinctly truncate at base, inflated throughout; stylus minute and slender, three or four cells long: underleaves distant, rhombic-obovate, narrowed and not at all cordate at base, bifid about one half, with acute lobes and sinus, margins angular-unidentate on sides: leaf-cells with somewhat thickened reddish-walls, trigones and intermediate thickenings distinct: ♀ inflorescence borne on a principal branch; bracts in two or three pairs, increasing in size toward the perianth, unequally bifid, the lobe broadly ovate, rounded at the apex, entire or slightly sinuate; lobule lanceolate or ovate-lanceolate, acute, or obtuse and apiculate, bearing a lobe-like tooth or stylus at the middle of the inner edge on the innermost bracts, close to the base on the others, otherwise entire; bracteole slightly connate on one side or free, ovate, bifid about one half with acute lobes and sinus, entire or sparingly laciniate-toothed on the sides; perianth more than half exserted, obovate, truncate above and abruptly narrowed into a short beak, with a broad, usually two-angled keel postically and commonly with one to three low supplementary keels on both surfaces, roughened or very sparingly tuberculate, at least on the keels: ♂ bracts in two to ten pairs, occupying a short branch and forming a globose or oblong spike.

Stems 0.09^{mm} in diameter, lobes of leaves 0.4 x 0.3^{mm}, lobules 0.14 x 0.12^{mm}, underleaves 0.14 x 0.15^{mm}, leaf-cells at edge of lobe 12μ, in the middle 15μ, and at the base 18μ in diameter, bract I, lobe 0.7 x 0.5^{mm}, lobule 0.6 x 0.17^{mm}, bracteole I, 0.5 x 0.25^{mm}, bract II, lobe 0.5 x 0.4^{mm}, lobule 0.4 x 0.15^{mm}, bracteole II, 0.35 x 0.17^{mm}, perianth 1.1 x 0.75^{mm}.

On trees. Oahu: Nuuanu (Cooke); first collected on the island by Meyen. Kauai: Kipu, Lihue, Half Way Bridge (Cooke).

Frullania Oahuensis is the smallest known Hawaiian *Frullania*, being even smaller than *F. Meyeniana*, with which it often grows and which it somewhat resembles. The regularly pinnate habit of this latter species and its clavate instead of galeate lobule will at once serve to distinguish it. The North American *F. Virginica* Gottsche is a much closer ally of *F. Oahuensis*, but is a somewhat larger plant in all its parts, and its leaves are more strongly cordate at the base.

The type-specimens of *F. Oahuensis* are apparently not to be found in the Gottsche Herbarium at Berlin. There is, however, a drawing so labeled among the beautiful "Icones Hepaticarum Ineditæ," and this agrees so closely with the specimens collected by Mr. Cooke that I have no hesitancy in pronouncing them the same.

3. Frullania Sandvicensis Ångstr. emend.

Frullania Sandvicensis Ångstr. Öfversigt af Kongl. Vetensk. Akad. Förhand. xxix, Häft 4, 28. 1872 (in part).
Frullania squarrosa Auct. (not *F. squarrosa* (R. Bl. & N.) Dum.).
Frullania arietina Aust. Bull. Torr. Bot. Club, 5 : 15. 1874 (not Tayl.).

Plate XLV., figs. 1-7.

Dioicous; growing in wide depressed tufts, often mixed with mosses or other hepatics, brownish-green, sometimes tinged with reddish: stems irregularly pinnately branched: leaves densely imbricated, more or less squarrose when moist, the lobe broadly ovate, arching over the stem and cordate, both at the antical base and at the keel, rounded at the apex, entire, slightly revolute on postical margin; lobule galeate throughout the whole or the greater part of its extent, hood inflated in upper and outer parts, compressed below; stylus small, subulate: underleaves imbricated, broadly orbicular or reniform, bifid about one fifth with broad obtuse or apiculate lobes and lunulate sinus, more or less cordate and channeled at base, margins entire or nearly so: leaf-cells rather thick-walled with very conspicuous trigones and intermediate thickenings: ♀ inflorescence borne on a short simple branch; bracts in two or three pairs, unequally bifid, the lobe ovate or obovate, obtuse or rounded at the apex, entire; lobule ovate, acute or acuminate, sparingly and irregularly toothed on the inner edge, one of the teeth (the stylus) being more distinct and larger than the others; bracteole connate on one side, ovate, bifid one fourth to one third with acute or acuminate teeth and narrow sinus, sparingly and coarsely toothed on the margins; perianth oblong-obovate, truncate above and abruptly narrowed into a short beak, strongly one-keeled postically and bearing on the surface numerous papilla-like or lobe-like projections, especially on the two lateral keels: ♂ bracts in about six pairs, occupying a short branch and forming a short, oval spike.

Stems 0·2^{mm} in diameter, lobes of leaves 1 x 0.9^{mm}, lobules 0.32 x 0.28^{mm}, underleaves 0.65 x 0.85^{mm}, leaf-cells at edge of leaf 16μ in diameter, in the middle 28 x 19μ, at the base 30μ in diameter, bract I, lobe 1.5 x 0.9^{mm}, lobule 1.3 x 0.6^{mm}, bracteole I, 0.95 x 0.7^{mm}, bract II, lobe 1.5 x 1^{mm}, lobule 1 x 0.6^{mm}, bracteole II, 0.9 x 0.75^{mm}, perianth 2.3 x 1.35^{mm}.

On rocks and trees. Oahu: Lulihi (Wawra); Nuuanu (Heller, Cooke); foot of Konahuanui (Cooke); Luakaha (Cooke); first collected on the island by Andersson. Kauai: Hanalei, Kilohana,

Lihue, Half Way Bridge (Cooke). Hawaiian Islands (Hillebrand, Mann and Brigham).

The determination of this species is based on the sterile type-material, preserved in the Royal Academy of Science at Stockholm. It is apparently the plant which has been referred by Austin and other authors to the widely distributed and variable *F. squarrosa*, and it is somewhat questionable as to whether the two are really distinct. When well developed, *F. Sandvicensis* is a little more robust than *F. squarrosa*, its leaves are less strongly squarrose, and its leaf-cells have somewhat better developed trigones. The underleaves, however, offer the best point of distinction: these are much broader than in *F. squarrosa*, often completely concealing the lobules, they are less deeply bifid, with broad lobes and sinus, and their margins are usually entire. These differences, although slight, are apparently constant. The distinctive characters between this species and *F. Aongstroemii* have already been pointed out and there is little likelihood of confusing it with any other Hawaiian species.

III. Subgenus Diastoloba Spruce.

4. **Frullania apiculata** (R. Bl. & N.) Dum.

Jungermannia apiculata R. Bl. & N. Nova Acta Acad. Caes.-Leop. xii, 222. 1825.
Frullania apiculata Dum. Receuil d'Obs. sur les Jung. 13. 1835.
Frullania explicata Mont. Ann. des Sc. Nat. II. xix, 256. 1843.
Frullania oceanica Mitt.; Seemann, Flora Vitiensis, 417. 1871.

Plate XLVI.

Autoicous: plants growing in wide depressed tufts, dark red varying to blackish or greenish: stems more or less regularly pinnate: leaves imbricated, the lobe ovate, arching over the stem but scarcely if at all cordate at base, decurved and abruptly apiculate at the apex, entire; lobule clavate, sometimes short enough to be called galeate, distant from the axis, truncate at base, inflated throughout; stylus minute, close to the lobule, borne on a broad reflexed base; underleaves subimbricated, broadly orbicular, somewhat cordate at base, bifid about one-third with acute lobes and sinus, margins entire, plane or slightly reflexed, sometimes revolute close to the base: leaf-cells with thick reddish walls, trigones and intermediate thickenings conspicuous, often becoming confluent: ♀ inflorescence borne on the main stem or a principal branch; bracts in three or four pairs, unequally bifid, the lobe ovate-lanceolate, acumi-

nate, entire; lobule slightly narrower than the lobe, long-acuminate, bearing a small slender tooth or stylus near the middle of the inner edge, otherwise entire or slightly angular-sinuate near the base; bracteole ovate, bifid about two fifths with acuminate lobes and narrow sinus, margins entire or nearly so; perianth about two fifths exserted, oblong, rounded at the apex and abruptly narrowed into a short beak, finely ciliolate at the mouth, sharply and narrowly keeled postically, smooth: ♂ spike terminal on a short, simple branch, bracts in about two pairs: capsule borne on a stalk about as long as the perianth; spores greenish with numerous minute reddish verruculæ arranged in small circular patches.

Stems 0.17^{mm} in diameter, lobes of leaves 0.7 x 0.5^{mm}, lobules 0.17 x 0.8^{mm} (in other cases, 0.15 x 0.12^{mm}), underleaves 0.35 x 0.4^{mm}, leaf-cells at edge of leaf 10μ in diameter, in the middle 14μ and at the base 30 x 20μ, bract I, lobe 2 x 0.75^{mm}, lobule 1.8 x 0.6^{mm}, bracteole I 1.8 x 1^{mm}, bract II, lobe 1.5 x 0.7^{mm}, lobule 1.3 x 0.4^{mm}, bracteole II 1.3 x 0.85^{mm}, perianth 2.5 x 1^{mm}, capsule 0.75^{mm} in diameter, spores 45-55μ in diameter, patches of verruculæ about 4μ wide.

On rocks and trees. Hawaii (Beechey, Macræ). Oahu: Lulumahu and Nuuanu (Cooke); also collected by Mann and Brigham. West Maui (Baldwin). Hawaiian Islands (Gaudichaud, Hillebrand). The species is widely distributed in the Malayan Archipelago, in southern Africa, and among the islands of the Pacific.

As Schiffner* has lately pointed out, the original description of *Frullania apiculata* states that the perichætial bracts and bracteoles are incised-serrate. The authors of the Synopsis Hepaticarum, however, applied the name to a plant with entire bracts and bracteoles and all subsequent authors have done the same thing. If the type-specimens in the Nees Herbarium should turn out to be pure *Frullania serrata* Gottsche, as Schiffner thinks probable, then the name of this species should be changed to *F. apiculata*, and the plant which is at present known by this name should be called something else. Herr Stephani writes me that the *Frullania explicata* of Montagne, of which he has seen the original specimens, is the same as the *F. apiculata* of the Synopsis; and, therefore, if any change of names becomes necessary, the plant with entire bracts and bracteoles should be called *F. explicata* Mont. It is quite possible, however, that the two species are mixed in the type-material, in which case of course no change would be required.

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* Conspect. Hep. Arch. Ind. 321. 1898.

The cell-structure of *F. apiculata* has already been figured by Schiffner,* who gives numerous interesting details about it. The inflorescence seems to be variable. All the fertile specimens from the Hawaiian Islands which I have seen are autoicous, while a Javan specimen kindly sent me by Herr Stephani, bears antheridia only. According to Gottsche,† the var. α of the Synopsis is monoicous, while the var. β is dioicous.

Frullania apiculata is a species which is intermediate between the subgenera *Thyopsiella* and *Diastoloba* of Spruce, and might be placed in the former perhaps better than in the latter. One of its closest allies, however, is *Frullania exilis* Tayl., of South America, and, as Spruce himself refers this species to *Diastoloba* (probably on account of its autoicous inflorescence), I have referred *F. apiculata* to the same subgenus. The South American species is much smaller in all its parts than *F. apiculata*, its leaf-lobes are very abruptly and minutely apiculate, its lobules are more slender, and the divisions of its bracts are more abruptly acuminate.

Of *F. oceanica* Mitt., the author has kindly sent me an authentic specimen from the island of Tahiti, which agrees very closely with the Hawaiian specimens above described. A second species of the Pacific islands, *F. Pacifica* Tayl., seems to be very close to *F. apiculata*, but is described as having subdentate bracts.

5. **Frullania Meyeniana** Lindenb.

Frullania Meyeniana Lindenb.; G. L. & N. Syn. Hep. 455. 1845.
Frullania Kunzei Aust. Bull. Torr. Bot. Club, v, 15. 1874 (not Lehm. & Lindenb.).
Frullania Helleri Steph. Bull. de l'Herb. Boissier, v, 845. 1897.

Plate XLV., figs. 8-14.

Autoicous: plants closely appressed to substratum, scattered or forming thin patches of considerable extent, dark red or purple, often almost black: stems, at least when young, regularly pinnate or bipinnate: leaves somewhat imbricated, the lobe ovate, arching over the stem but not cordate at base, slightly decurved at the rounded apex, convex, entire; lobule clavate, close to axis and parallel with it, rounded at base, inflated throughout; stylus minute, filiform, consisting of three or four cells in a single row: underleaves distant, obovate, cuneate and not at all cordate at base, bifid about

* Nova Acta Acad. Cæs.-Leop. lx, 224. *pl. 6. f. 28-30.* 1893.
† Abhandl. d. Bremen Natur. Vereine, vii, 363. 1882.

two fifths with obtuse or rounded lobes and narrow sinus, entire or angular-unidentate on sides: leaf-cells thick-walled, with distinct trigones and occasional intermediate thickenings, often becoming confluent: ♀ inflorescence borne on a principal branch; bracts in two or three pairs, the lobe ovate, acute or obtuse (away from perianth), entire or sparingly and irregularly angular-dentate, lobule ovate-lanceolate, acute or short-acuminate, angular-dentate (on innermost bract, two to four teeth on each side) or subentire, bearing a slender cilium-like stylus near the base on the inner edge; bracteoles free from bracts, ovate, bifid almost to middle, with divisions similar to the lobules of the bracts; perianth about half exserted, oblong-obovate, rounded at the apex and narrowed into a rather long beak, ciliate at the mouth, with a narrow postical keel and smooth surface: ♂ spike globose, usually borne just below the involucre; bracts in about three pairs: capsule borne on a very short stalk; spores yellowish-brown, verruculose, the verruculæ in small circular patches.

Stems 0.14^{mm} in diameter, lobes of leaves from 0.5–0.85^{mm} long, 0.4–0.75^{mm} wide, lobules 0.17 x 0.08^{mm}, underleaves 0.25 x 0.15^{mm}, leaf-cells at edge of lobe 16μ in diameter, in the middle 20μ, at the base 25 x 23μ, bract I, lobe 0.95 x 0.45^{mm}, lobule 0.85 x 0.25^{mm}, bracteole I 0.75 x 0.5^{mm}, bract II, lobe 0.7 x 0.35^{mm}, lobule 0.85 x 0.17^{mm}, bracteole II 0.5 x 0.25^{mm}, perianth 1.35 x 0.7, capsule 0.5^{mm} in diameter, spores 40–50μ in diameter, patches of verruculæ about 5μ wide.

On trees. Oahu: Nuuanu (Heller, Cooke); Luakaha, Mt. Tantalus, foot of Konahuanui (Cooke); first collected on the island by Meyen; also collected by Mann and Brigham. Kauai: Kilohana (Cooke). West Maui (Baldwin).

My determination of this species is based on the original description and on a drawing of a sterile fragment kindly sent me by Herr Stephani, who had examined the original material. The most important difference which this author points out between *F. Meyenaina* and his recently published *F. Helleri* is in regard to the bracts. In the diagnosis of *F. Meyeniana* in the Synopsis, the involucre is briefly and inadequately described as "integerrimum," whereas in Herr Stephani's description of *F. Helleri* the bracts are said to be "acuta vel apiculata, angulatim paucidentata, lobulis duplo angustioribus . . . . . acuminatis paucidentatis." As my description shows, the characters drawn from the involucre are very variable, and this is true even of the specimens of *F. Helleri* sent me by Mr. Heller himself. I have, therefore, been unable to keep the two species distinct.

In its essential characters, *Frullania Meyeniana* is almost intermediate between *F. Donnellii* of Florida, and *F. Kunzei* of the southern United States, the West Indies and Brazil, two species which are themselves very closely allied. The best points of distinction are found in the perichætial bracts and bracteoles: in *F. Donnellii*, the lobes and lobules of the bracts and the divisions of the bracteoles (at least of the innermost row) are strongly incised-dentate; in *F. Meyeniana*, the lobes are subentire, but the lobules and the divisions of the bracteoles are coarsely dentate; while in *F. Kunzei*, the divisions of both bracts and bracteoles are entire or nearly so. In a sterile condition *F. Meyeniana* differs from both the American species in its more closely imbricated leaves and narrower lobules, which are closer to the stem and to each other.

6. **Frullania hypoleuca** Nees.

Frullania hypoleuca Nees; G. L. & N. Nova Acta Acad. Leop.-Car. xix, suppl. 1, 470. 1843.

Plate XLVII., figs. 1-11.

Autoicous: plants at first closely appressed to substratum, afterwards forming wide and intricate, depressed mats, yellowish-green varying to reddish: stems at first rather regularly bipinnate, some of the branches (especially the ultimate ones) microphyllous and of short limited growth: leaves densely imbricated, the lobe orbicular-ovate, arching over the stem but not cordate at base, slightly decurved at the rounded or obtuse, sometimes minutely apiculate apex; lobule clavate, distant from the axis, widely spreading or subparallel, rounded at the base, inflated throughout; stylus about a third as long as the lobule, obliquely triangular from a broad base, with its apex close to the lobule: underleaves imbricated, orbicular, bifid about one third, with broad, spreading or connivent, obtuse, acute, or apiculate lobes and wide sinus, cuneate and not at all cordate at base, entire or sinuately toothed on the sides: leaf-cells with conspicuous, often confluent trigones and occasional intermediate thickenings: ♀ inflorescence borne on a principal branch; bracts in about three pairs, the lobe ovate to obovate (on innermost bract), apiculate at the apex, entire or sparingly and coarsely toothed in the upper part, lobule narrowly ovate or lanceolate, acute and apiculate, bearing a distinct lobe-like tooth or stylus near or below the middle of the inner edge and sometimes a few minute and irregular teeth nearer the base, otherwise entire; bracteoles free

or the innermost slightly connate on one side, ovate, bifid about two fifths with broad, acute lobes and acute or obtuse sinus, entire or unidentate on the sides; perianth about one fourth exserted, obovate-oblong, cuneate toward base, truncate above and narrowed into a short beak, ciliate at the mouth, with a narrow postical keel and smooth surface: ♂ spikes borne single or in pairs close to the perianth; bracts in two or three pairs: capsule exserted on a very short stalk; spores yellowish-brown with minute, darker verruculæ collected in circular patches.

Stems 0.17^{mm} in diameter, lobes of leaves 1 x 0.85^{mm}, lobules 0.25 x 0.1^{mm}, underleaves 0.6 x 0.6^{mm}, leaf-cells at edge of lobe 17μ in diameter, in the middle 22μ, and at the base 25μ; bract I, lobe 2 x 1^{mm}, lobule 1.7 x 0.6^{mm}, bracteole I 1.6 x 0.95^{mm}, bract II, lobe 1.35 x 0.8^{mm}, lobule 1 x 0.45^{mm}, bracteole II, 0.85 x 0.5^{mm}, perianth 2.2 x 1.2^{mm}, capsule 0.75^{mm} in diameter, spores 40-50μ in diameter, the patches of verruculæ about 6μ wide.

On trees. Oahu: Panoa (Heller); Nuuanu, Mt. Tantalus (Cooke); first collected on the island by Meyen. West Maui (Baldwin). Sandwich Islands (Gaudichaud).

The marked resemblance between the *Frullaniæ* of the Hawaiian Islands and those of the southern United States is a matter of some interest. With the exception of *F. apiculata*, each of the six species described above has one or more close allies from the latter region, and in some cases the resemblance is very striking indeed. As has been pointed out, *F. Aongstromeii* is close to *F. arietina*, *F. Sandvicensis* to *F. squarrosa*, *F. Oahuensis* to *F. Virginica* and *F. Meyeniana* to *F. Donnellii* and *F. Kunzei*. *F. hypoleuca* finally finds a close ally in *F. Caroliniana*. The American plant, however, is considerably smaller and less densely pinnate; its leaves are less imbricated and their lobes more uniformly spreading, the divisions of its bracts and bracteoles are less pointed and always entire, and its perianth is proportionately broader at the apex.

2. **JUBULA** Dum.

The genus *Jubula* as first proposed by Dumortier in 1822,* included the two modern genera *Jubula* and *Frullania*. In 1831,† he divided his genus into two sections, *Jubulotypus*, for his *J. Hutchinsiæ*, and *Ascolobium*, for his *J. dilatata* and *J. tamarisci* (now *Frullania dilatata* and *F. tamarisci* respectively). In 1835‡ he raised his two

* Comm. bot. 112. † Sylloge Jungermann. 36.

‡ Receuil d'obs sur les Jung. 12.

sections to generic rank, retaining the name *Jubula* for his section *Jubulotypus*, and applying to his section *Ascolobium* the older name *Frullania* of Raddi, of whose work he had until then apparently been ignorant. This arrangement is adhered to in his latest work on the Hepaticæ, published in 1874.*

For many years other writers on the subject, both in Europe and in America, did not agree with these final views of Dumortier, but included both genera under the name *Frullania*. In 1884,† however, Spruce pointed out more clearly than Dumortier had done the differences between the two, and since this time, they have been almost universally recognized.

The type of the genus is *Jubula Hutchinsiæ* (Hook.) Dum., a very local plant of Great Britain. Forms similar to this type have been found in eastern North America, in tropical America, in Asia, and in several islands of the Pacific, and these various forms have, with very few exceptions, been referred to *J. Hutchinsiæ* as varieties. There is no doubt that these so-called varieties are very closely related to each other, and it is probable that some of them are merely temporary conditions of others. Still, as the differences between certain of them are very well marked and seem to be constant, it is doubtful if anything is to be gained by trying to keep them together. All the Hawaiian material which I have seen can be referred to the single species:

1. **Jubula piligera** (Aust.) Evans.

Frullania Hutchinsiæ Auct. (not (Hook.) Dum.).
Frullania (*Jubula*) *piligera* Aust. Bull. Torr. Bot. Club, vi, 301. 1879.
Jubula piligera Evans, Trans. Conn. Acad. viii, 253. 1891.

Plate XLVII., figs. 12–20.

Autoicous: growing in flat tufts, dark green: stems irregularly pinnate: leaves imbricated, the lobe broadly ovate, reflexed or plane at the acuminate apex, entire or sometimes sparingly ciliate-dentate (with one to three teeth) near the apex, arching to about the middle of axis and neither rounded nor cordate at base; lobule galeate, distant from axis and spreading or subparallel, flattened, appearing clavate when seen from edge, narrowed at the obliquely truncate base, inflated throughout; stylus very early obsolete: underleaves ovate-orbicular, rounded toward the base and slightly decurrent, bifid

* Hep. Europ. 25, 26.

† Hep. Amaz. et And. 59.

one third to one half with acuminate lobes and acute sinus, entire or sparingly ciliate-dentate (with one or two teeth) on the sides; leaf-cells rather thick-walled with small but distinct trigones and occasional, vague, intermediate thickenings: ♀ inflorescence borne on a principal branch with innovations on one or both sides, the innovations themselves usually floriferous and innovating on one side; bracts in a single pair, the lobe ovate-oblong, narrowed into a long, acuminate point, entire or sparingly ciliate-dentate (with one or two teeth), lobule ovate-lanceolate, long-acuminate, entire (the stylus apparently obsolete); bracteole ovate, free from bracts, bifid about two fifths with acuminate lobes and acute sinus, markedly narrowed toward base, entire or with one or two cilia near apex; perianth obovate, gradually narrowed toward base, rounded or truncate at apex and narrowed into a short beak, with a high, narrow, postical keel, smooth: ♂ spikes long and slender, arising singly or in pairs near the involucre and in the position normal for vegetative branches; bracts in six or more pairs, smaller than the stem-leaves, complicate-bilobed and concave, imbricated but not densely so, the lobes ovate and acuminate, lobules smaller, ovate, acute; bracteoles similar to the other underleaves but smaller.

Stems 0.2^{mm} in diameter, lobes of leaves 1.1 x 0.8^{mm}, lobules 0.3 x 0.2^{mm}, underleaves 0.6 x 0.65^{mm}, leaf-cells at edge of lobe 13μ in diameter, in the middle 25 x 14μ, and at the base 32 x 19μ, lobe of bract 1.7 x 0.7^{mm}, lobule 1.1 x 0.5^{mm}, bracteole 1.7 x 1^{mm}, perianth 2.4–2.9^{mm} long, 0.95^{mm} wide.

On the ground and on trunks of trees in damp places. West Maui (Baldwin). Kauai (Baldwin). Hawaiian Islands (Tolmie). Oahu: Konahuanui (Cooke).

Although the present species was considered distinct by Austin, Schiffner* accords it specific rank very doubtfully, and Stephani† reduces it to a simple synonym of *Jubula Hutchinsiæ*. The following characters, however, would seem sufficient to distinguish it: its leaf-lobes are usually entire except for the apical tooth, which is longer and slenderer than in *J. Hutchinsiæ;* when other teeth are present, they too are slender; the lobule does not end in a slender point, but is constricted and truncate at the mouth; the bracts and bracteoles are larger and less toothed (frequently not toothed at all) and are tipped with slender points; the ♂ branches are long, extending far beyond the stem-leaves, and they arise in the same way as ordi-

* Engler & Prantl, Natürl. Pflanzenfam. i^3, 132. 1893.

† Bull. de l'Herb. Boissier, v, 842. 1897.

nary branches; the bracts are less closely imbricated, sometimes scarcely touching, and the branch sometimes bears small unmodified leaves beyond the bracts; the bracts have the same texture as ordinary leaves and are not delicate as in *J. Hutchinsiæ;* the ordinary leaf-cells have slightly thicker walls and are more elongated in the middle and toward the base of the lobe.

Subtribe II. LEJEUNEEÆ.

The generic limits of the forms included in the Lejeuneeæ have been subject to considerable discussion, and the opinions of hepaticologists are still somewhat diverse concerning them. The old genus *Lejeunia*, as first proposed by Mlle. Libert* nearly eighty years ago, was made up of the two European species, *L. serpyllifolia* and *L.* (now *Cololejeunea*) *calcarea*. In 1831, Dumortier† added to the genus the European species, *calyptrifolia*, *hamatifolia* and *minutissima*, and in 1835,‡ made a few more additions, mainly of tropical species, at the same time separating *L. calyptrifolia* as the type of a distinct genus, *Colura*. A few years afterwards, Nees von Esenbeck§ also recognized the genus *Lejeunea*, placing in it the same European species as Dumortier.

The publication of the Synopsis Hepaticarum in the next decade brought into the genus an immense number of exotic species, many of which had been previously described under the convenient old generic name, *Jungermannia*. In this way the number of known species of *Lejeunea* was increased to nearly three hundred. At the same time the authors of the Synopsis recognized or proposed the closely related genera *Bryopteris*, *Thysananthus*, *Ptychanthus* and *Phragmicoma*,‖ which were made up almost entirely of extra-European forms. The characters assigned to these genera were in some cases both vague and false, but they were made use of by authors in a rather blind way, until the publication of Spruce's important work in 1884. This author pointed out the untrustworthy and artificial characters of certain of the Synopsis genera and proceeded to combine, in the single, much-embracing genus *Lejeunea*, all those Jubuloideæ which are constantly monogynous. He then divided his genus into thirty-seven divisions, most of which are natural and well-defined. These

* Ann. Gen. des Sci. Phys. (Brux.) vi, 372. 1820.

† Sylloge Jungermann. 32.

‡ Receuil d'obs. sur les Jung. 11.

§ Naturgeschichte der europ. Lebermoose, iii, 255. 1838.

‖ First proposed by Dumortier for the European *P. Mackaii* (Hook.) Dum.

divisions he called "subgenera" and gave to each of them a name in which the word "Lejeunea" was compounded with an appropriate, descriptive prefix (e. g. *Sticto-Lejeunea*, *Neuro-Lejeunea*, etc.). This work of Spruce is his most important contribution to hepaticology, and by its means he brought a certain degree of order into a group which had heretofore been almost hopeless, both on account of its inherent complexity and on account of the brief and inadequate descriptions of many of the older authors. Spruce pointed out clearly in his writings that his so-called subgenera or, at any rate, some of them were really the equivalents of acknowledged genera in other groups of the Hepaticæ, but he continued to write of them as subgenera, and even in his last paper,* published after his death, they are so designated. Since 1885, most of the writers on Hepaticæ, who have busied themselves with exotic species, have made use of Spruce's divisions and have used his names, now as generic, now as subgeneric, in a somewhat inconsistent way. The tendency to consider these divisions as true genera, however, became more and more manifest, until, in 1893, Schiffner divided his Lejeuneeæ into forty distinct genera, most of which have the limits and the names of the subgenera of Spruce. In a few cases, the names of the Synopsis or other older names are substituted; as, for example, *Bryopteris* for *Bryo-Lejeunea* and *Marchesinia* for *Homalo-Lejeunea*. Many of these genera are undoubtedly distinct; others are probably too close to one another, and a more intimate knowledge of the group will doubtless show that some should be united. For the present, however, it seems wisest to recognize most of Schiffner's genera as such, and to use his names. It hardly seems just, nevertheless, to give up Mlle. Libert's old name *Lejeunea* altogether; as Schiffner himself suggests in a foot-note, this name might readily be retained for the genus which he calls *Eulejeunea*, more especially as the type of the old genus, *L. serpyllifolia*, is the type of the restricted genus as well. It is probable also that Spruce's subgenus *Micro-Lejeunea*, as restricted by Stephani,† is as well entitled to generic rank as certain of Schiffner's genera, although it is referred by him as a subgenus to *Eulejeunea*.

As Schiffner is the writer who first defined these groups as genera, he and not Spruce should be looked upon as authority for them, and the year 1893 should be considered the date of their establishment.‡

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* Hepaticæ Elliottianæ. Linn. Soc. Journ. Bot. xxx, 331–372. *pl. 20–30.* 1894.

† Hedwigia, xxix, 84. 1890.

‡ This should of course not apply to the old generic names given in the Synopsis and elsewhere.

An objection to this procedure may be found in the fact that other writers, notably Stephani, have used these names as generic, previous to 1893; but as these writers did not define their genera, it would complicate matters and be inconsistent with customary usage to quote them as authority for their new combinations, excepting of course those published since 1893.

Of the forty genera recognized by Schiffner, Stephani* accredits seventeen to the Hawaiian Islands, and the addition of *Microlejeunea* as a distinct genus makes eighteen. Two species, *L. ungulata* and *L. calyptrata* of Ångström, he leaves doubtful; the first of these is the same as Mitten's *L. uncinata* and is therefore a *Drepanolejeunea*, but the second belongs in the distinct genus *Colurolejeunea*. The writer is able to add the genus *Trachylejeunea* to the list, making twenty genera in all. It is evident, however, that this number is not quite correct: several of the genera are apparently listed on incorrect determinations and certain species appear to the writer to fit somewhat more naturally into other genera than those to which they have been assigned. By making these exclusions and transferences, fourteen genera are left. As many of these are represented by a single species each, it has seemed most practicable in the following key to lead directly to the species represented on the Islands, rather than to have short special keys under the respective genera.

Key to the species of Hawaiian Lejeuneeæ.

Underleaves present, normal in number (i. e. one for each pair of side-leaves).

Underleaves undivided.

Leaves entire.

♀ inflorescence borne on a principal branch, without innovations. *Lopholejeunea subnuda.*

♀ inflorescence borne on a very short branch, with a short, sterile innovation. (*Platylejeunea.*)

Underleaves broadly reniform. *Platylejeunea baccifera.*

Underleaves orbicular. *Platylejeunea cryptocarpa.*

♀ inflorescence borne on a principal branch, innovating on one or (very rarely) on both sides. *Brachiolejeunea Sandvicensis.*

Leaves usually more or less toothed at apex.

‡ Cf. Bull. de l'Herb. Boissier, v, 842. 1897. *Dicranolejeunea* is omitted from this list.

Underleaves decurrent, reflexed at apex.
Marchesinia Mittenii.
Underleaves not decurrent, plane at apex.
Thysananthus elongatus.

Underleaves bifid.
Leaves sharp-pointed.
Underleaves with broad lobes (consisting of ten to many cells), the sinus not extending beyond middle.
(*Harpalejeunea.*)
Leaves acute to acuminate, lobule large (about half as long as lobe).
Harpalejeunea pseudoneura.
Leaves apiculate, lobule small (about one sixth as long as lobe). *Harpalejeunea Owaihiensis.*
Underleaves with slender lobes (consisting of five to seven cells), the sinus extending beyond the middle.
(*Drepanolejeunea.*)
Leaves entire or denticulate, acute.
Drepanolejeunea Anderssonii.
Leaves incised-dentate, acuminate.
Drepanolejeunea uncinata.
Leaves rounded at apex or very blunt-pointed.
Leaves with two or three ocelli at base of lobe.
Ceratolejeunea oculata.
Leaves not ocellate.
Leaves obliquely spreading.
Leaf-cells thick-walled or papillose or both.
♀ inflorescence borne on a very short branch (the vegetative leaves represented by a single underleaf), not innovating or with a single, short innovation on one side; perianth with a distinct antical keel.
Trachylejeunea Oahuensis.
♀ inflorescence borne on a principal branch or on a short lateral branch (always with a few vegetative leaves), innovating on one or on both sides; perianth plane or nearly so on antical face.
(*Cheilolejeunea.*)
Underleaves contiguous or subimbricated.

Leaf-lobes about 1^{mm} long and 0.5^{mm} wide; cells with thin walls and scarcely evident trigones. *Cheilolejeunea stenoschiza.*

Leaf-lobes 0.5 – 0.6^{mm} long, 0.4–0.5^{mm} wide; cells with somewhat thicker walls and more distinct trigones. *Cheilolejeunea intertexta.*

Underleaves distant.

Leaf-cells with large, conspicuous trigones. *Cheilolejeunea Hawaica.*

Leaf-cells thin-walled, without trigones. *Cheilolejeunea Sandvicensis.*

Leaf-cells thin-walled, not papillose, sometimes with small trigones. (*Lejeunea.*)

Underleaves bifid to beyond the middle; leaf-cells without trigones; perianth retuse at apex. *Lejeunea Pacifica.*

Underleaves bifid to about the middle; leaf-cells with small trigones; perianth not retuse at apex. *Lejeunea anisophylla.*

Leaves erect-spreading. *Microlejeunea albicans.*

Underleaves absent. (*Cololejeunea.*)

Lobule more than half as long as lobe. *Cololejeunea Cookei.*

Lobule less than half as long as lobe.

Lobe not hyaline-margined, stylus reduced to a single cell, often obsolete.

Lobe less than twice as long as broad.

Perianth strongly compressed, with a low, broad, postical keel, deeply emarginate at apex; inflorescence autoicous.

♀ inflorescence borne on a very short branch, with a short sterile innovation; leaf-cells with conspicuous trigones. *Cololejeunea obcordata.*

♀ inflorescence borne on a principal branch, innovating on one side, the innovation often floriferous; leaf-cells without trigones. *Cololejeunea ceatocarpa.*

Perianth slightly compressed with a high, two-angled postical keel, not retuse at apex; inflorescence dioicous. *Cololejeunea ovalifolia.*

Lobe more than twice as long as broad. *Cololejeunea Hillebrandii.*

Lobe hyaline-margined, at least near apex.

Stylus reduced to a single cell, often obsolete; lobule plane. *Cololejeunea lanciloba.*

Stylus composed of several cells, lobule inflated. *Cololejeunea longistylis.*

Underleaves present, doubled (i. e. two for each pair of side-leaves); leaves ending in a long, inflated sac. *Colurolejeunea tennicornis.*

3. **LOPHOLEJEUNEA** (Spruce) Schiffn.

Lejeunea subgenus *Lopho-Lejeunea* Spruce, Hep. Amaz. et And. 119. 1884.

Lopholejeunea Schiffn.; Engler & Prantl, Nat. Pflanzenfam. i[3], 129. 1898.*

Plants medium-sized to large, brown or brownish-green, sometimes deeply tinged with purple or almost black, closely appressed to substratum or growing in depressed and intricate tufts: stems irregularly pinnate: leaves imbricated, falcate-ovate, entire; the lobule small, acutely or obtusely pointed at the apex, otherwise entire: underleaves imbricated, orbicular to reniform, entire, slightly or not at all decurrent at base: leaf-cells with more or less thickened walls: ♀ terminal on a principal branch, without innovations; bracts larger than the leaves, the lobe usually denticulate to laciniate, at least at the apex, lobule small, sometimes indistinct; bracteole subrotund with a broad apex, usually entire; perianth somewhat compressed with two distinct postical keels, both these and the lateral keels tuberculate or alate with dentate to laciniate wings: ♂ spike elongated, terminal on a simple branch or occupying its whole length.

In Herr Stephani's list,† the genus *Lopholejeunea* is credited with four Hawaiian species, viz:—*L. subnuda*, *L. gibbosa*, *L. Mannii* and *L. Owahuensis.* I have been able to examine type-specimens of all of these and find that they should be referred to a single species, to

* A fuller synonymy of this and of the following genera of the Lejeuneeæ is given by Schiffner. The characters of the various genera are given in full both by this author and by Spruce, and the generic descriptions in the present paper are largely compiled from the works of these writers.

† Bull. de l'Herb. Boissier, v, 842. 1897.

which, accordingly, the oldest of these four specific names should be applied.

1. **Lopholejeunea subnuda** (Mitt.) Steph.

Phragmicoma subnuda Mitt.; Seemann, Flora Vitiensis, 412. 1871.
Lejeunea gibbosa Ångstr. Öfversigt af Kongl. Vetensk. Akad. Förhand. xxix, Häft 4, 23. 1872.
Lejeunea (*Phragmicoma*) *Mannii* Aust. Bull. Torr. Bot. Club, v, 15. 1874.
Lopholejeunea Owahuensis Steph. Hedwigia, xxxv, 11. 1896.
Lopholejeunea gibbosa Steph. Bull. de l'Herb. Boissier, v, 842. 1897.
Lopholejeunea Mannii Steph. l. c.
Lopholejeunea subnuda Steph. l. c.

Plate XLVIII., figs. 1–6.

Autoicous: plants closely appressed to substratum, but usually growing in wide, depressed mats, dark olive-green or purplish, sometimes almost black: stems irregularly pinnately branched: leaves imbricated, the lobe convex, more or less decurved at the rounded or very obtuse apex, broadly ovate, arching over the stem but scarcely beyond, not cordate at base, entire; lobule broadly triangular-ovate from a broad base (when explanate), keel slightly arched, not decurrent, free margin entire, strongly involute near base, plane and very bluntly pointed at the apex, then gradually passing into lobe: underleaves contiguous or slightly imbricated, reniform, entire, attached by a curved line of insertion, but scarcely decurrent: leaf-cells papillose with indistinct and often confluent trigones and intermediate thickenings: ♀ inflorescence borne on a long principal branch, sometimes giving off branches near the bracts, but very rarely true innovations; bracts scarcely bifid, the lobule appearing as a narrow entire, rectangular expansion attached to lobe by its whole length, lobe ovate, more or less dentate at the rounded apex and along antical margin, the teeth short, sharp or blunt, and rarely more than six in number; bracteole free, ovate to obovate-quadrate, attached by a narrow base, truncate or slightly emarginate at apex, entire; perianth about half exserted, obovate or cuneiform, gradually narrowed toward base, rounded or truncate at apex and abruptly narrowed into a short beak, somewhat compressed on sides, with two distinct postical keels and often with a low antical keel, keels more or less winged, the wings undulate, dentate or laciniate: ♂ spike borne on a simple branch near the involucre, occupying the

whole branch or terminal, bracts in many pairs (sometimes twelve or more), imbricated, concave, smaller than ordinary leaves, subequally bifid with entire divisions rounded at the apex; bracteoles smaller than the other underleaves but otherwise similar to them.

Stems 0.14^{mm} in diameter, lobes of leaves 1 x 0.7^{mm}, lobules when explanate 0.3 x 0.2^{mm}, underleaves 0.5 x 0.65^{mm}, leaf-cells at edge of lobe 16μ in diameter, in the middle 25μ, and at the base 32 x 25μ, lobe of bract 1.4 x 0.75^{mm}, lobule 0.5 x 0.08^{mm}, bracteole 0.95 x 0.8^{mm}, perianth 1.55 x 0.9^{mm}.

On trees and banks. Oahu: Luakaha, Nuuanu, foot of Konahuanui (Cooke); also collected by Andersson, by Didrichsen, and by Mann and Brigham. Kauai: Kilohana (Cooke). Hawaiian Islands (Hillebrand).

Although in this species there are usually no branches in the vicinity of the involucre, specimens will occasionally offer an exception to this rule. In such cases branches may arise very close to the perianth, in very rare instances in fact appearing as true innovations. Such specimens, however, are so entirely like typical plants in other respects, that it would be artificial to separate them, much more so to place them in distinct genera. The crests on the perianth of *L. subnuda* are very variable: sometimes they are narrow and very slightly sinuate or sinuate-dentate on the margins; sometimes they are broader and sharply laciniate-dentate: it is, however, possible to find many intermediate conditions.

A close ally of the Hawaiian species is the widely distributed *Lopholejeunea Sagraeana* (Mont.) Schiffn., which is likewise autoicous. This species is, however, smaller, its leaves increase rapidly in size toward the perianth, and this latter organ is almost immersed in the involucre and very strongly laciniate on the keels. *L. eulopha* (Tayl.) Schiffn., found in various Pacific islands, has spinose bracts and bracteoles and is dioicous.

On the strength of specimens collected by Mr. Heller, Herr Stephani has listed as a Hawaiian plant a species found on the Marianne Islands, namely, *Archilejeunea Mariana* (Gottsche) Steph.* Through the kindness of Professor Underwood, who is now in possession of Mr. Heller's hepatics, I have been enabled to examine a large number of specimens so named, but find among them no *Lejeunea* with undivided underleaves excepting *Lopholejeunea subnuda*. It is of course possible that the *Archilejeunea* occurred in

* Bull. de l'Herb. Boissier, v, 842. 1897.

small amount in the specimens forwarded to Herr Stephani for determination, but was wanting in the rest of the collection. On account of the uncertainty concerning it, however, the species is omitted from the present account.

4. **PLATYLEJEUNEA** (Spruce) Schiffn.

Lejeunea subgenus *Platy-Lejeunea* Spruce, Hep. Amaz. et And. 124. 1884.

Platylejeunea Schiffn. ; Engler & Prantl, Nat. Pflanzenfam. i^3, 130. 1893.

Plants large to very large, brown or blackish-brown, creeping or pendulous: stems irregularly pinnate: leaves somewhat imbricated, the lobe horizontally spreading, ovate, usually more or less incurved at apex and recurved along postical margin, entire, usually rounded or obtuse at apex; lobule small, strongly inflated and cucullate near axis: underleaves large, more or less imbricated, orbicular to reniform, broadly truncate or retuse, entire, often decurrent: leaf-cells with large and distinct trigones: ♀ inflorescence borne on a very short branch, with a single, short, sterile innovation on one side; bracts much smaller than the leaves, subequally bifid, entire; bracteole narrow, obtuse or more or less indented at apex; perianth small, oblong or obovate, rounded to emarginate at apex, strongly compressed, margins more or less incised-fimbriate, surface smooth or with a few scattered papillæ, antical surface plane, postical surface with two to four low, usually spinose keels: ♂ terminal on a principal branch or on a short special branch, bracts in many pairs.

Two species of *Platylejeunea* have been accredited to the Hawaiian Islands. The first of these, *P. baccifera*, as Herr Stephani has already pointed out,* was at first incorrectly referred to *Lejeunea transversalis*, a plant of tropical America. I have examined the Hawaiian material labeled *Jungermannia transversalis*, var., in the herbarium at Kew and find that it agrees closely with the Australian type-specimen of *Phragmicoma baccifera* in the same collection. Of the second species, *P. cryptocarpa*, the type-specimens have been kindly sent me by Mr. Mitten. Apparently neither of these species has been collected on the Islands since 1793.

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* Hedwigia, xxix, 13. 1890.

1. **Platylejeunea baccifera** (Tayl.) Steph.

Lejeunea transversalis, β, Hookeriana G. L. & N. Syn. Hep. 311. 1845.

Phragmicoma baccifera Tayl. Lond. Jour. Bot. v, 387. 1846.

Marchesinia baccifera Trevis. Mem. reale Ist. Lomb. di Sci. e Lett. III. iv, 405. 1877.

Platylejeunea baccifera Steph. Hedwigia, xxix, 6. 1890. Also in herb.

Plate LXVIII., figs. 7–11.

Dioicous: plants brown: stems sparingly and irregularly pinnately branched: leaves imbricated, the lobe ovate, slightly convex, somewhat decurved at the rounded or very obtuse apex, arching over the axis but scarcely beyond, slightly or not at all cordate at base, entire or rarely obscurely crenulate at apex; lobule triangular-ovate (when explanate), much inflated near axis, keel strongly arched, often somewhat decurrent, free margin entire, very strongly involute near base, plane and almost straight in outer half: underleaves imbricated, broadly reniform, plane or nearly so, attached by a sharply curved line of insertion and abruptly short-decurrent or indistinctly cordate at base, apex broadly truncate or retuse, margin entire or sparingly and obscurely crenulate: leaf-cells with large trigones and occasional intermediate thickenings, often becoming confluent: ♀ bracts subequally one fourth to one third bilobed, lobes and lobules ovate to oblong, rounded to subacute, entire or very obscurely crenulate at the apex from projecting cells; bracteole obovate from a narrow cuneate base, shortly bifid (about one twelfth) with obtuse lobes and sinus, entire; perianth (very young) compressed, dentate on lateral keels: ♂ inflorescence not seen.

Stems 0.25^{mm} in diameter, lobes of leaves 1.7 x 1.1^{mm}, lobules when inflated 0.35 x 0.25^{mm}, underleaves 0.9 x 1.5^{mm}, leaf-cells at edge 22μ in diameter, in the middle 29μ, and at the base 35μ, lobe of outer bract 0.95 x 0.5^{mm}, lobule 1 x 0.4^{mm}, bracteole 0.9 x 0.6^{mm}.

Hawaii (Menzies).

The above description is drawn from a specimen kindly given me by Herr Stephani, which fully agrees with the material at Kew. *Platylejeunea baccifera* is very close to *P. transversalis* (Swartz) Schiffn., but is apparently still closer to *P. granulata* (Nees) (*Lejeunea tæniopsis* Spruce), also of tropical America. It is distinguished from the first of these by its smaller lobules and by the narrower bases of its underleaves. It differs from the second in its broader underleaves, and there are apparently slight differences also in involucre and

perianth, the bracteole of *P. granulata*, for example, being truncate or obtuse, while that of *P. baccifera* is shortly bifid. My material of the latter species is, however, too young to make full comparisons and the published descriptions of the floral organs are very incomplete.

2. **Platylejeunea cryptocarpa** (Mitt.) Steph.

Lejeunea cryptocarpa Mitt.; Seemann, Flora Vitiensis, 413. 1871.
Platylejeunea cryptocarpa Steph. Bull. de l'Herb. Boissier, v, 842. 1897.

Dioicous: plants greenish-brown: stems sparingly and irregularly branched: leaves imbricated, the lobes ovate, slightly convex, plane or somewhat decurved at the rounded apex, arching across the axis and usually a little beyond, slightly or not at all cordate at base, entire; lobule triangular-ovate, much inflated near axis, keel slightly arched, indistinctly decurrent, free margin entire, strongly revolute near axis, plane in outer half: underleaves somewhat imbricated, orbicular, broadly rounded at the apex, plane or nearly so, short-decurrent or vaguely cordate at base, attached by a sharply curved line of insertion, entire: leaf-cells with distinct trigones and occasional intermediate thickenings, often becoming confluent: ♀ bracts subequally one third bifid, the divisions ovate to oblong, the lobe usually subacute and the lobule obtuse to truncate, margin slightly crenulate from projecting cells; bracteole obovate-oblong, bifid about one third with rounded lobes and narrow sinus, slightly crenulate; perianth (young) compressed, obovate, antical surface plane, postical surface with a broad two-angled keel, lateral keels and two angles of postical keel with distinct and sharply incised-dentate wings: ♂ spike oblong, occupying a short special branch; bracts in about six pairs, bracteoles wanting, except at base of spike.

Stems 0.2^{mm} in diameter, lobes of leaves 1.2 x 0.75^{mm}, lobules when inflated 0.2 x 0.15^{mm}, underleaves 0.7 x 0.7^{mm}, leaf-cells at edge of leaf 16μ in diameter, in the middle 26μ, and at the base 28μ, lobe of bract 0.6 x 0.25^{mm}, lobule 0.5 x 0.25^{mm}, bracteole 0.7 x 0.35^{mm}, ♂ spike 1 x 0.5^{mm}.

"On *Leptogium azureum*." Hawaii (Menzies).

It will be seen from the foregoing description that this species is very close to *P. baccifera*. It is, nevertheless, smaller in all its parts and its underleaves are strikingly different in shape, so that the two should probably be kept separate. It is to be regretted that the Hawaiian material of this interesting genus is so meager and incom-

plete. As Herr Stephani has remarked, the vegetative characters of the species are exceedingly variable, and it is rarely possible to describe one of them in a satisfactory way without an extensive series of specimens.

5. **BRACHIOLEJEUNEA** (Spruce) Schiffn.

Lejeunea subgenus *Brachio-Lejeunea* Spruce, Hep. Amaz. et And. 129. 1884.

Brachiolejeunea Schiffn.; Engler & Prantl, Nat. Pflanzenfam. i^3, 128. 1893.

Plants medium-sized to large, green or brownish-green, closely appressed to substratum or growing in depressed intricate tufts: stems irregularly pinnate or dichotomous: leaves imbricated, the lobe falcate, entire; lobule much smaller than lobe, denticulate on margin: underleaves imbricated, orbicular to reniform, slightly cordate or decurrent at base: leaf-cells with distinct trigones: ♀ inflorescence terminal on a principal branch, innovating on both or, more rarely, on only one side; bracts often smaller than the leaves; perianth slightly or not at all compressed, three- to ten-keeled: ♂ spike elongated, variously situated.

1. Brachiolejeunea Sandvicensis (Gottsche).

Phragmicoma bicolor Mont. Voyage de la Bonite, Botanique, i, 223. 1846 (not *Lejeunea bicolor* (Nees) Mont.).

Phragmicoma Sandvicensis Gottsche, Ann. des Sciences nat. IV, viii, 344. *pl. 15. f. 10–24.* 1857.

Phragmicoma subsquarrosa Aust. Proc. Acad. Nat. Sci. Phil. for 1869: 225.

Lejeunea subsquarrosa Aust. Bull. Torr. Bot. Club, v, 15. 1874.

Mastigolejeunea Sandvicensis Steph. Hedwigia, xxviii, 29. 1889. Bull de l'Herb. Boissier, v, 842. 1897.

Lejeunea Sandvicensis Evans, Trans. Conn. Acad. viii, 253. 1892.

Brachiolejeunea Gottschei Schiffn. Hedwigia, xxxiii, 186. *pl. 8, 9. f. 20–31.* 1894.

Phragmicoma Japonica Gottsche Ms.; Schiffn. l. c. (as synonym).

Brachiolejeunea Japonica Steph. Bull. de l'Herb. Boissier, v, 842. 1897.

Dioicous: plants brownish- or glaucous-green, closely appressed to substratum or more commonly forming wide depressed mats, often growing in company with other bryophytes: leaves densely imbricated, wrapped about the stem when dry, explanate and more or less

squarrose when moist, the lobe ovate, arching across but not beyond stem, scarcely rounded at the base, rounded at the apex, entire; lobule (when explanate) ovate, strongly inflated its whole length, keel slightly arched, not decurrent, appearing crenulate from its strongly papillose cells, free margin appressed to lobe, denticulate with three or four short blunt teeth: underleaves imbricated, reniform, slightly cordate at base, entire or very slightly crenulate from projecting cells: leaf-cells papillose with small and distinct trigones and intermediate thickenings, rarely becoming confluent, marginal cells of lobe short and squarish, forming a more or less distinct edge: ♀ inflorescence borne on a principal branch, almost invariably with a single innovation; outer bract (away from innovation) shortly bifid, lobe broadly ovate or orbicular-ovate, rounded at apex, entire, lobule ovate, rounded or very obtuse at the apex, entire; inner bract (next innovation) elobulate, broadly orbicular-ovate, rounded at apex, entire; bracteole orbicular, free, truncate at apex, entire or faintly crenulate from projecting cells; perianth not compressed, truncate and slightly retuse at apex, with a short beak, deeply eight- to ten-plicate, keels slightly crenulate from papillose cells: ♂ spike not seen: spores oblong, greenish, with a thick yellowish wall, densely and minutely tuberculate and with scattered circular patches of radiating plate-like thickenings.

Stems 0.2^{mm} in diameter, lobes of leaves 1 x 0.8^{mm}, lobules 0.4 x 0.25^{mm}, underleaves 0.4 x 0.6^{mm}, cells at edge of lobe 18μ in diameter, in the middle 30μ, at the base 41 x 30μ, lobe of outer bract 1.5 x 1.1^{mm}, lobule 0.7 x 0.5^{mm}, inner bract 1.35 x 1.45^{mm}, bracteole 1.2 x 1.1^{mm}, perianth 1.3–1.5^{mm} long, 0.8–0.9^{mm} wide, spores 40μ in shortest diameter.

On rocks and trees. Oahu: near Diamond Point (Didrichsen); Nuuanu, Luakaha (Cooke); also collected by Andersson. Kauai: Kilohana, Kipu, Lihue, Half Way Bridge (Cooke). West Maui (Baldwin). Hawaiian Islands (Hillebrand, Mann and Brigham). First collected on the Islands by Gaudichaud.

As the long synonymy indicates, the generic position of this abundant species has been a matter of considerable controversy. The fact that the perianth innovates almost invariably on only one side would seem to throw it out of the genus *Brachiolejeunea*. Schiffner, however, in his description of *B. Gottschei*, states that a double innovation, although extremely rare, is occasionally found. The pluriplicate perianth and the lobules of the leaves (with respect to their shape and free margins) are quite characteristic of *Brachio-*

lejeunea and indicate a certain affinity with *B. bicolor* (Mont.) Schiffn., to which Montagne originally referred the Hawaiian plant. It differs from this species of tropical America in its more squarrose leaves, in the less recurved postical margins of their lobes, and in their larger cells, in its single innovation, in its wingless outer bract, and in its undivided inner bract. This last character indeed is a most unusual one for the genus, and, so far as I know, does not occur in any other species. In a sterile condition, *B. corticalis* (Lehm. & Lindenb.), likewise of tropical America, resembles the present species very closely, but differs in its larger lobule and less papillose leaf-cells.

The original material of *Brachiolejeunea Gottschei* from Japan (or Java) is in the Gottsche Herbarium at Berlin and agrees closely with the Hawaiian plant. The species has also been reported from China by Professor Massalongo, who describes the inflorescence as polyoicous.*

6. **MARCHESINIA** S. F. Gray.

Marchesinia S. F. Gray, Nat. Arr. Brit. Pl. i, 689. 1821 (as "*Marchesinus*").

Phragmicoma Dumort. Com. bot. 112. 1822.

Lejeunea subgenus *Homalo-Lejeunea* Spruce, Hep. Amaz. et And. 132. 1884.

Plants large, brown or greenish-brown, usually growing in depressed tufts: stems irregularly pinnate or more commonly dichotomously branched: leaves more or less imbricated, the lobe ovate to orbicular-ovate, widely spreading, entire throughout, or apiculate and more or less toothed near apex; lobule small, plane or slightly inflated, usually with one to four teeth on free margin; underleaves large, often imbricated, orbicular to reniform, more or less cordate and decurrent at base, margin entire to dentate-spinulose: leaf-cells with more or less thickened walls: ♀ inflorescence borne on a principal branch, innovating on both sides; bracts narrower than the leaves, the lobe usually spinulose, lobule small, entire; bracteole obovate, truncate or emarginate, usually more or less toothed on margin; perianth obovate, strongly compressed, plane on both surfaces, or with a low postical keel, truncate or retuse at apex, entire or indistinctly winged on lateral keels: ♂ inflorescence variously situated, often hypogynous or within a fork, with few to many bracts.

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* Mem. dell' Accad. di Art. e Comm. di Verona, lxxiii, 35. 1897.

1. **Marchesinia Mittenii** sp. nov.

Plate XLVIII., figs. 12–14.

Dioicous: plants brownish-green: stems irregularly pinnately branched: leaves slightly imbricated, the lobe ovate, horizontally spreading, plane or slightly convex, arching over the stem and rounded but scarcely cordate at base, rounded and usually apiculate at the apex, entire or sparingly dentate near apex (with one to three blunt teeth on each side of apical tooth); lobule slightly inflated, subquadrate from a short base, keel strongly arched, not decurrent, forming almost a right angle with postical margin of lobe, free margin of lobule at first parallel with stem, then turning at a right angle and passing into the postical margin of lobe, the two forming a straight, continuous line, margin of lobule bearing about three blunt teeth, the one farthest from the stem being the largest: underleaves slightly imbricated, broadly obovate, reflexed at the broad, rounded apex, gradually narrowed toward the decurrent and slightly cordate base and attached by a long, sharply curved line of insertion, entire or very sparingly denticulate on reflexed margin: leaf-cells with thick trigones and intermediate thickenings, occupying nearly the whole of the wall: ♀ bracts deeply and unequally bifid, the lobe obovate, rounded at the apex and sparingly dentate above the middle, lobule ovate to lanceolate, acute, entire; bracteole broadly orbicular-obovate form a narrow base, rounded or truncate at apex, sharply dentate, the teeth about twenty in number, mostly three to six cells long and two to four cells wide at base; underleaf next bracteole sparingly dentate, but with shorter teeth: perianth and ♂ spike not seen.

Stems 0.25^{mm} in diameter, lobes of leaves 1.5 x 1^{mm}, lobules 0.25 x 0.3^{mm}, underleaves 1.2 x 1.2^{mm}, cells at edge of lobe 21μ in diameter, in the middle 27μ, and at the base 43 x 35μ, lobe of bract 2 x 1.2^{mm}, lobule 0.5 x 0.25^{mm}, bracteole 1.5 x 1.4^{mm}.

Hawaiian Islands (Hillebrand), mixed with the type-specimens of *Lopholejeunea subnuda* (Mitt.) Steph.

The plant described above is known only from the fragmentary type-specimens without perianths in Mr. Mitten's herbarium, but it undoubtedly belongs in this genus. It resembles very closely *Marchesinia robusta* (Mitt.) Schiffn. of tropical America, but this species is amply distinct in having more densely imbricated leaves and spinulose-denticulate underleaves.

7. THYSANANTHUS Lindenb.

Thysananthus Lindenb.; G. L. & N. Syn. Hep. 286. 1845.
Lejeunea subgenus *Thysano-Lejeunea* Spruce, Hep. Amaz. et And. 105. 1884.
Lejeunea subgenus *Dendro-Lejeunea* Spruce, l. c. 110.
Lejeunea subgenus *Phragmo-Lejeunea* Schiffn. & Gottsche, Lebermoose der Forschungsreise S. M. S. "Gazelle," 24. 1890.

Plants large, green or brownish-green, usually in depressed tufts: stems growing from a more or less distinct creeping caudex, pinnately or dichotomously branched, sometimes with slender flagelliform branchlets: leaves imbricated, the lobe ovate to ligulate, usually more or less recurved on postical margin, entire or usually somewhat dentate near apex, lobule small, more or less inflated, with one or two minute teeth on free margin near apex: underleaves ovate to orbicular, narrowed toward base, truncate to broadly emarginate at the entire or denticulate apex: leaf-cells with distinct trigones, more or less elongated in the middle and toward the base of lobe: ♀ inflorrescence borne on a stem or principal branch, innovating on one or on both sides, the innovations usually floriferous; bracts unequally bifid, the lobe narrower than in the leaves, entire or toothed, lobule small; bracteole truncate or shortly bifid, mostly dentate; perianth linear to obovate, trigonous but sometimes with supplementary keels, the keels usually dentate- or laciniate-winged: ♂ inflorescence terminal or intercalary on a principal branch.

1. Thysananthus elongatus (Aust.).

Phragmicoma elongata Aust. Proc. Acad. Nat. Sci. Phil. for 1869: 225.
Lejeunea aliena Ångstr. Öfversigt af Kongl. Vetensk. Akad. Förhandl. xxix, Häft 4, 23. 1872 (misprinted "*L. alcina*").
Lejeunea elongata Aust. Bull. Torr. Bot. Club, v, 17. 1874.
Dicranolejeunea Didericiana Steph. Hedwigia, xxxv, 77. 1896.
Brachiolejeunea aliena Steph. Bull. de l'Herb. Boissier, v, 842. 1897.
Ptycholejeunea elongata Steph. l. c.

Plate XLIX.

Autoicous or dioicous: plants brownish-green, sometimes bright or yellowish-green, very variable, in some cases closely appressed to substratum but usually growing in wide depressed mats: stems irregularly pinnate, or, on fruiting plants, usually diochotomous: leaves imbricated, sometimes densely so, not squarrose, the lobe

falcate-ovate, arching to about the middle of axis, rounded but not cordate at base, entire or, usually, with a few (one to five) short blunt teeth near the apex, the apical tooth being the largest, margin often somewhat revolute; lobule (when well developed) ovate from a narrow base, narrowing at first abruptly, then more gradually, keel arched, distinctly decurrent at base, free margin strongly involute at base, plane in outer part, entire or with a single more or less distinct blunt apical tooth; lobule often very poorly developed: underleaves distant or contiguous, broadly obovate-orbicular, gradually narrowed toward base, slightly decurrent, truncate and often reflexed at apex, entire or minutely crenulate or denticulate in upper part, rarely slightly retuse: leaf-cells with conspicuous trigones and intermediate thickenings, often becoming confluent near apex and margin of lobe: ♀ inflorescence on a principal branch, with one or usually two innovations; bracts deeply and unequally bifid, the lobe oblong or ovate, apiculate at the rounded apex, subentire or usually sparingly dentate in upper part (two or three irregular teeth on each side of apex), entire below, lobule lanceolate, acuminate, entire or nearly so; bracteole free, orbicular-ovate, truncate or rarely shortly bifid at the apex, entire or commonly coarsely and irregularly dentate above the middle; perianth obovate, rounded above and abruptly narrowed into a short beak, more or less compressed on sides, grooved and with one large and usually two small supplementary keels on antical surface, on postical surface with a broad, three- or four-plicate keel, the keels indistinctly and interruptedly winged, entire or slightly sinuate-denticulate: ♂ spike terminal or intercalary on a large branch, bracts in about five pairs, imbricated, subequally and shortly complicate-bilobed, with blunt, broad, subentire divisions, margin of lobule often revolute; bracteoles similar to the other underleaves, usually entire: spores oblong, green, with a thick whitish wall, minutely tuberculate.

Stems 0.17^{mm} in diameter, lobes of leaves 1.35 x 0.85^{mm}, lobules 0.35 x 0.2^{mm}, underleaves 0.45 x 0.55^{mm}, cells at edge of lobe 13μ in diameter, in the middle 21 x 17μ, at the base 32 x 17μ, lobe of bract 1.1 x 0.55^{mm}, lobule 0.5 x 0.2^{mm}, bracteole 0.8 x 0.65^{mm}, perianth 1.9 x 0.85^{mm}, capsule 0.5^{mm} in diameter, spores 30μ in shortest diameter.

On rocks and trees. The type-specimens collected by Hillebrand. Oahu: Konahuanui (Heller, Cooke); Nuuanu, Luakaha, Palolo (Cooke); also collected by Andersson and by Didrichsen. Kauai: Half Way Bridge (Cooke); also collected by Baldwin.

The determination of this extremely variable species is based on a part of Austin's original material, which I owe to the kindness of Mr. Pearson. These plants are much elongated and sparingly branched and very few of them show any signs of inflorescence; in fact, I have been able to find only two perianths upon them, each of which is subtended by a single innovation. Similar elongated forms are found among Mr. Cooke's specimens, and these, like the type, are almost invariably sterile. A few of them, however, show unfertilized female flowers which are innovant, sometimes on only one side, but usually on both. The more common form of the species appears somewhat different from these elongated conditions: the stems are shorter and are almost always fruiting, and the female flowers are innovant on both sides, giving the plants thereby a forked appearance. Even here, however, a one-sided innovation is very frequent. Although these two extreme forms appear so unlike, they are connected with each other by numerous intermediate conditions. They also agree so perfectly in their leaves with their apical teeth and decurrent keels, in their leaf-cells, in their underleaves, and in their floral leaves and perianths, that it is impossible to draw a line between them.

The type-specimen of Ångström's *Lejeunea aliena*, kindly sent me by Professor Nathorst, is very similar to that of *Phragmicoma elongata*, while the type of *Dicranolejeunea Didericiana* is more like the usual form of the species. Herr Stephani has recently published, as *Brachiolejeunea apiculata* n. sp.,* a plant collected by Mr. Heller on Oahu. The type of this species appears to be inaccessible: there are no specimens so named among Mr. Heller's plants in New York, and Herr Stephani's own specimens seem to have been mislaid. The author, however, has had the kindness to send me a drawing made from the original material, which shows a leaf, an underleaf, and a perianth with its involucre. Judging from this drawing and from the published description, the plant is very close to *Thysananthus elongatus* and may be a form of it, as the differences brought forward could easily be accounted for by the very great variability of the species. The matter, however, must be left in doubt for the present.

The widely distributed *Thysananthus fruticosus* Lindenb. & Gottsche differs from *T. elongatus* in its vittate leaves and in the much sharper and more numerous teeth on its leaves, underleaves, bracts and perianth, as well as in the different shape of the last named

* Bull. de l'Herb. Boissier, v, 846. 1897.

organ. Judging from the figure given by Sande-Lacoste,* a much closer ally of the Hawaiian plant is the Javan *Thysananthus polymorphus* (S.-L.) Schiffner,† particularly the variety *planifolia.* Through the kindness of Professor Schiffner, I have been able to examine an authentic specimen of this species from the Berlin Herbarium and find that it is considerably larger than *T. elongatus*, that its leaves are commonly entire and more pointed and that their lobules are different in shape.

8. **HARPALEJEUNEA** (Spruce) Schiffn.

Lejeunea subgenus *Harpa-Lejeunea* Spruce, Hep. Amaz. et And. 164. 1884 (in great part).

Harpalejeunea Schiffn.; Engler & Prantl, Nat. Pflanzenfam. i³, 126. 1893.

Strepsilejeunea Schiffn. l. c. 127.

Plants medium-sized to minute, pale green, varying to brownish- or grayish-green, closely appressed to substratum, sometimes subcæspitose: stems sparingly and irregularly pinnate: leaves contiguous or slightly imbricated, widely spreading, somewhat decurved and acute or acuminate at apex, entire, crenulate or subdentate on margins, rarely incised-dentate; lobule variable in size, inflated: underleaves distant, small to large, rotund to cuneate in outline, bifid with blunt or subacute segments, rarely undivided: leaf-cells small, sometimes a few of them ocellate: ♀ inflorescence borne on a short branch, sometimes simple, sometimes innovating on one, or more rarely, on both sides; bracts and bracteoles larger than the leaves; perianth pyriform to obovate, five-keeled, keels crenulate, roughened or spinose: ♂ spike occupying a short branch or terminal on a longer branch, bracts few, antheridia one or two in each axil.

The genus *Strepsilejeunea*, first proposed by Spruce as a section of his subgenus *Harpa-Lejeunea*, is recognized by Schiffner in a somewhat tentative way, and also by Stephani. It is certainly very close indeed to *Harpalejeunea.* The most important differences enumerated by Schiffner are the following: the larger size of the plants, their darker color, the leaves toothed and reflexed at the apex, the distinctly thickened walls of their cells, the larger underleaves. These differences do not appear to be very constant. I have therefore not tried to separate the genera, but have referred to *Harpalejeunea* the

* Syn. Hep. Jav. 58. *pl. 11.* 1856.

† Conspect. Hepat. Arch. Ind. 305. 1898.

Lejeunea Owaihiensis of Gottsche, a plant which Stephani has placed in *Strepsilejeunea.*

1. **Harpalejeunea pseudoneura** sp. nov.

Plate L., figs. 1–9.

Dioicous: plants pale green, closely appressed to substratum or creeping among other hepatics: stems sparingly branched: leaves subimbricated, the lobe widely spreading, falcate-ovate, acute and usually somewhat decurved at apex, margins minutely crenulate or subdentate; lobule ovate, lunately truncate at apex, the apical tooth curved so strongly as almost to touch end of keel, keel arched, crenulate from papillose cells, free margin almost straight, strongly involute as far as apical tooth: underleaves obovate from a narrow base, bifid about one half with erect or slightly spreading, obtuse or subacute lobes and obtuse or lunulate sinus, entire or angular-unidentate on sides: leaf-cells with slightly thickened walls, trigones scarcely apparent, ocelli in a continuous line, running from the base of lobe almost to apex: ♀ inflorescence borne on a short branch, innovating on one side with a simple innovation; bracts unequally bifid, the lobe ovate, somewhat falcate (less so than leaves), acute, crenulate and angular-dentate on margins, lobule ovate-lanceolate, acute or apiculate, crenulate and usually angular-dentate; bracteole free, oval or ovate, bifid about one fourth with obtuse or subacute lobes and narrow sinus, crenulate and often angular-dentate; perianth obovate, truncate and slightly retuse at apex, sharply five-keeled in upper part, the keels rounded above and crenulate on margins from papillose cells: ♂ spike terminal on a somewhat elongated branch; bracts in two to five pairs, subequally bifid with obtuse or subacute lobes, crenulate on margins and keel; bracteoles absent from upper part of spike; antheridia borne singly.

Stems 0.05^{mm} in diameter, lobes of leaves 0.35 x 0.15^{mm}, lobules 0.17 x 0.1^{mm}, underleaves 0.12 x 0.12^{mm}, cells at edge of lobe 14μ in diameter, in the middle and at the base 16μ, ocelli 25 x 16μ, lobe of bract 0.45 x 0.2^{mm}, lobule 0.25 x 0.13^{mm}, bracteole 0.35 x 0.25^{mm}, perianth 0.85 x 0.4^{mm}.

On trees or creeping among other hepatics. Oahu: Nuuanu and Konahuanui (Cooke).

The ocelli, which are found in several species of this genus, usually occur in small numbers at the base of the lobe. Their arrangement in a continuous line is an interesting character of the

Hawaiian plant, and this, together with the peculiar underleaves, will serve to distinguish it from certain South American species, which it otherwise somewhat resembles.

2. **Harpalejeunea Owaihiensis** (Gottsche).

Lejeunea Owaihiensis Gottsche; G. L. & N. Syn. Hep. 351. 1845.
Lejeunea (*Strepsi-Lejeunea*) *Owaihiensis* Steph. Hedwigia, xxix, 74. 1890.
Strepsilejeunea Owaihiensis Steph. Bull. de l'Herb. Boissier, v, 842. 1897.

Plate L., figs. 10–14.

Plants yellowish: stems sparingly and irregularly pinnately branched: leaves somewhat imbricated, the lobe widely spreading, broadly ovate, abruptly apiculate or acute, very rarely obtuse at the apex, margin minutely crenulate from projecting cells and sometimes sparingly and indistinctly denticulate; lobules more or less covered by the underleaves, inflated, triangular-ovate, the keel very slightly arched, free margin involute and almost straight in inner half, lunate at apex with a sharp apical tooth: underleaves broadly orbicular, not overlapping, slightly cordate at base and attached by a somewhat curved line of insertion, bifid one fourth to one third with acute lobes and broad, lunulate sinus, margin minutely crenulate from projecting cells: leaf-cells rather thin-walled, without trigones.

Stems 0.1^{mm} in diameter, lobes of leaves 0.45 x 0.35^{mm}, lobules 0.08 x 0.07^{mm}, underleaves 0.25 x 0.28^{mm}, cells at edge of lobe 13μ in diameter, in the middle 16μ, at the base 19 x 16μ.

Hawaii (Menzies).

The above description is drawn from a portion of the original material kindly sent me by Dr. Hennings of the Royal Botanical Museum at Berlin. The specimens examined are all of them sterile, and it is probable that Gottsche himself did not see the perianths. The ♀ inflorescence, however, is described in the Synopsis as follows: "fructu ad basin ramorum sessili, foliis involucralibus amphigastrioque dentato-serratis, illorum lobulo magno truncato." Spruce compares this species with his *Lejeunea* (*Harpa-Lejeunea*) *pilifera** of South America, but this latter plant is amply distinct in its cuspidate leaves and much smaller underleaves.

* Hep. Amaz. et And. 170. 1884.

9. **DREPANOLEJEUNEA** (Spruce) Schiffn.

Lejeunea subgenus *Drepano-Lejeunea* Spruce, Hep. Amaz. et And. 185. 1884.

Drepanolejeunea Schiffn.; Engler & Prantl, Nat. Pflanzenfam. i^3, 126. 1893.

Plants small or minute, green to yellowish-green, creeping over other bryophytes: stems sparingly branched: leaves distant or contiguous, obliquely spreading or almost erect, the lobe acuminate or acute and more or less decurved at apex, crenulate, spinulose or laciniate on the margins; lobule ovate, inflated: underleaves distant, small, deeply bifid with subulate lobes: leaf-cells with thin or slightly thickened walls, a few of them sometimes ocellate: ♀ inflorescence terminal on a short branch, with a single innovation on one side; bracts and bracteoles slightly modified; perianth five-keeled, the keels dilated into horizontally spreading toothed horns: ♂ inflorescence occupying a sharp branch or terminal on a longer branch.

Drepanolejeunea and *Harpalejeunea* are very closely related genera, but the leaves of the first are oblique or erect-spreading and usually so strongly decurved at the apex that they give the plants a peculiar appearance, enabling us at once to recognize them. The most essential difference between the genera is to be found in the underleaves: in *Drepanolejeunea* these are small and bifid to or beyond the middle and their divisions are subulate and sharp-pointed and usually widely divaricate; in *Harpalejeunea* the underleaves are larger and less deeply bifid, never beyond the middle, and their divisions are broad and blunt-pointed or, more commonly, rounded at the apex. There are also differences in the floral organs, particularly in the perianths.

1. **Drepanolejeunea Anderssonii** (Ångstr.).

Lejeunea Anderssonii Ångstr. Öfversigt af Kongl. Vetensk. Akad. Förhand. xxix, Häft. 4, 24. 1872.

Harpalejeunea Anderssonii Steph. Bull. de l'Herb. Boissier, v, 142. 1897.

Plate LI., figs. 1–9.

Autoicous: plants closely appressed to matrix, yellowish-green: stems irregularly branched: leaves distant or contiguous, the lobe erect-spreading, ovate from a narrow base, acute, entire or with one or two small blunt teeth on antical margin; lobule ovate, inflated along keel and near base, keel strongly arched, forming an almost

continuous curve with postical margin of lobe, free margin of lobule plane and appressed to lobe except close to the base, lunate at apex with a curved apical tooth: underleaves distant, deeply bifid, the divisions widely spreading or, on poorly developed stems and branches, erect or only slightly divergent, subulate, three or four cells long, two cells wide at base, separated by a broad, obtuse or lunulate sinus: leaf-cells with somewhat thickened walls, the trigones and intermediate thickenings indistinct and more or less confluent; ocelli scarcely larger than the other cells, two or three in number, scattered, sometimes wanting: ♀ inflorescence borne on a very short branch, innovating on one side; bracts unequally bifid, the lobe ovate, acute, entire or subdentate, lobule ovate, acute, usually unindentate on inner side near apex; bracteole free, ovate to obovate, bifid about one third with narrow acuminate lobes and sinus, entire or nearly so; perianth cuneiform in outline, broadly truncate at apex and with a broad beak, sharply five-keeled in upper part, the keels prolonged as horizontally spreading acute horns, entire or denticulate at apex: ♂ spike occupying a short branch, globose or oval; bracts in one to three pairs, with entire lobes, bracteoles small, usually at base of spike only, bifid about one third, with narrow suberect divisions, similar to the underleaves on small branches: spores oblong, green, slightly verruculose.

Stems 0.04^{mm} in diameter, lobes of leaves 0.3 x 0.15^{mm}, lobules 0.2 x 0.1^{mm}, underleaves 0.1 x 0.2^{mm}, or on smaller branches 0.08 x 0.06^{mm}, cells at edge of lobe 18 x 16μ, in the middle and at base 25 x 16μ, lobe of bract 0.35 x 0.15^{mm}, lobule 0.3 x 0.07^{mm}, bracteole 0.3 x 0.12^{mm}, perianth 0.6 x 0.4^{mm}, capsule 0.2^{mm} in diameter, spores 16 to 21μ in diameter.

On trees or on living leaves. Oahu: Konahuanui (Cooke); first collected on the island by Andersson.

Through the kindness of Professor Nathorst, I have been able to examine the type-material of this distinct little species. It consists of a few fragmentary stems and upon one of these is an old and battered perianth, whose involucre has been largely worn away. The description which I had drawn from these specimens has been supplemented by the more complete material collected during the past summer by Mr. Cooke. His specimens show that the underleaves are somewhat variable in shape: on robust stems and branches, their lobes are widely divaricate, while on smaller stems and branches they may be erect or nearly so. It is in fact quite usual to find both these conditions upon an individual plant. The larger size of *D.*

Anderssonii and the subentire lobes of its leaves, acute but not acuminate at the apex, will at once distinguish it from the following species.

2. **Drepanolejeunea uncinata** (Mitt.) Steph.

Lejeunea uncinata Mitt.; Seemann, Flora Vitiensis, 416. 1871.
Lejeunea ungulata Ångstr. Öfversigt af Kongl. Vetensk. Akad. Förhand. xxix, Häft 4, 25. 1872.
Drepanolejeunea uncinata Steph. Bull. de l'Herb. Boissier, v, 842. 1897.

Plate LI., figs. 10–18.

Autoicous: plants creeping over other bryophytes, pale green: stems slender, sparingly and irregularly branched: leaves distant or contiguous, the lobe ovate to lanceolate, obliquely spreading, long-acuminate and deflexed forward at apex, antical margin on robust leaves with two or three sharp teeth, postical margin with a single blunter tooth next the keel, margins on poorly developed leaves often entire; lobule ovate, lunately truncate at apex, with distinct apical tooth, strongly inflated, keel arched, free margin strongly involute to beyond apical tooth: underleaves bifid to within one or two cells of base, the lobes slightly spreading, subulate, two cells wide at base and three or four cells long, sinus lunulate: leaf-cells with slightly thickened walls, the very indistinct trigones and intermediate thickenings more or less confluent; ocelli two or three, scattered: ♀ inflorescence borne on a very short branch, innovating on one side with a long sterile innovation; bracts unequally bifid, the lobe rhombic or obovate, acuminate, coarsely dentate on margins (two to four teeth on each side), lobule tooth-like, acute, entire or with a single tooth near apex; bracteole free, ovate to obovate, bifid about one third with acute or acuminate lobes and narrow sinus, with about three coarse teeth on each side; perianth obovate, truncate above and with a short beak, almost terete below, sharply five-keeled above, the keels running out into acute or acuminate almost horizontal horns or processes, slightly denticulate near the ends: ♂ spike occupying a very short branch, subglobose; bracts in one or two pairs, the divisions slightly dentate; bracteole usually single, very small: spores irregular in shape, more or less oblong, angular, green, with a thickened, whitish, minutely verruculose wall.

Stems 0.04^{mm} in diameter, lobes of leaves 0.3 x 0.17^{mm}, lobules 0.17 x 0.1^{mm}, underleaves 0.08 x 0.07^{mm}, cells at edge of lobe 18μ in diameter, in the middle and at the base 18 x 12μ, lobe of bract 0.35 x 0.17^{mm}, lobule 0.2 x 0.05^{mm}, bracteole 0.3 x 0.17^{mm}, perianth

0.5 x 0.3^{mm} long, 0.3^{mm} wide, capsule 0.2^{mm} in diameter, spores 20–25μ in shortest diameter.

On *Bazzania* and *Cryptopodium*. The type-specimens collected by Gaudichaud. Oahu: Nuuanu and Konahuanui (Cooke); also collected by Andersson.

Drepanolejeunea tridactyla (Gottsche) of Java, is very close to the Hawaiian plant, but has mamillate leaf-cells. The South American *D. palmifolia* (Nees) Schiffn. is a somewhat larger plant, the teeth on its lobes are more numerous (varying from five to ten on robust leaves), and the bracts are more laciniate. My description of *D. uncinata* is drawn from Mr. Cooke's specimens, which closely agree with the original material of the species, kindly sent me by Mr. Mitten, and also with the type-specimen of *Lejeunea ungulata*, received from Professor Nathorst.

10. **CERATOLEJEUNEA** (Spruce) Schiffn.

Lejeunea subgenus *Cerato-Lejeunea* Spruce, Hep. Amaz. et And. 198. 1884.

Ceratolejeunea Schiffn.; Engler & Prantl, Nat. Pflanzenfam. i^3, 125. 1893.

Plants medium-sized, yellowish to blackish-green, growing in flat mats: stems irregularly branched: leaves contiguous to imbricated, the lobe widely spreading, falcate-ovate, rounded to subacute and often decurved at the apex, entire or crenulate, sometimes toothed near the apex, lobule small, inflated; leaves at base of a branch often modified into large inflated sacs: underleaves bifid: leaf-cells not papillose, with somewhat thickened walls, a few of the basal cells often ocellate: ♀ inflorescence borne sometimes on a short branch, sometimes on a larger branch, innovating on one or, more rarely, on both sides; bracts similar to the leaves, but the lobe often more sharply pointed and more toothed, and the lobule plane; bracteole larger than the underleaves; perianth with four or five keels, often prolonged above as horns, surface smooth or papillose: ♂ inflorescence occupying a special branch.

1. **Ceratolejeunea oculata** (Gottsche) Steph.

Lejeunea oculata Gottsche; G. L. & N. Syn. Hep. 357. 1845.

Ceratolejeunea oculata Steph. Bull. de l'Herb. Boissier, v, 842. 1897.

Plate LII., figs. 1–2.

Autoicous: plants brownish-green, creeping: stems irregularly branched: leaves contiguous or subimbricated, the lobe widely

spreading, arching to about the middle of axis, falcate-ovate, rounded or very obtuse at the apex, entire or minutely crenulate: lobule ovate, strongly inflated, obliquely truncate or lunulate at apex, apical tooth a slender apiculum, curved toward end of keel, keel arched, free margin more or less involute as far as apex: underleaves distant, orbicular, bifid about one half with acute or subacute lobes and narrow sinus: leaf-cells with slightly and uniformly thickened walls; ocelli two or three near base of lobe, thin-walled: ♀ inflorescence borne on a short, small-leaved, lateral branch, innovating on one side with a short simple innovation; bracts smaller than the leaves, the lobe oblong to obovate, obtuse to subacute, entire, lobule obovate, rounded or emarginate at apex, entire keel, narrowly winged (on outer bract); bracteole obovate, bifid about one fourth with obtuse or subacute lobes and sinus, entire; perianth not seen: ♂ spike occupying a short lateral branch; bracts in two or three pairs, subequally bifid; bracteole at base of spike small, the others wanting.

Stems 0.09^{mm} in diameter, lobes of leaves 0.4 x 0.35^{mm}, lobules 0.1 x 0.1^{mm}, underleaves 0.15 x 0.15^{mm}, cells at edge of lobe 9μ in diameter, in the middle 17μ, at the base 25 x 14μ, ocelli 40 x 21μ, lobe of bract 0.35 x 0.17^{mm}, lobule 0.2 x 0.1^{mm}, bracteole 0.3 x 0.17^{mm}.

On *Radula Javanica.* Hawaii (Menzies).

The description given above is drawn from a part of the type-material kindly furnished me by Herr Stephani. Gottsche describes the species as monoicous, but the fragmentary plants which I have studied seem to be unisexual, so that possibly the inflorescence is variable. According to Stephani* the perianth is four-keeled in the upper half, the keels being blunt and projecting upwards beyond the short beak. The same author also points out that *C. oculata* lacks the curious inflated leaves or utriculi, usually found at the base of a branch in species of this genus. It is not, however, unique in this respect, as several species of tropical America, where the genus is particularly well represented, show the same peculiarity. The species is placed by Spruce in his subgenus *Trachy-Lejeunea.*†

11. **TRACHYLEJEUNEA** (Spruce) Schiffn.

Lejeunea subgenus *Trachy-Lejeunea* Spruce, Hep. Amaz. et And. 180. 1884.

Trachylejeunea Schiffn.; Engler & Prantl, Nat. Pflanzenfam. i^3, 126. 1893.

Plants medium-sized, growing in depressed tufts or creeping among other bryophytes, pale, becoming brownish or purplish with

* Hedwigia, xxix, 76. 1890.

† Hep. Amaz. et And. 181. 1884.

age: stems irregularly pinnately branched: leaves more or less imbricated, the lobe ovate, widely spreading, mostly obtuse or subacute at apex, margin usually crenulate or serrulate from projecting cells, rarely dentate, lobule medium sized, inflated, rarely obsolete: underleaves suborbicular, usually small, bifid to about the middle with acute or obtuse lobes, entire on margin: leaf-cells with thickened walls, more or less papillose, ocelli present in a few species near base of lobe: ♀ inflorescence borne on a very short branch, without innovations or with a single sterile innovation; bracts longer than the leaves, bifid, subentire or usually crenulate; bracteole free, cuneate to oval, shortly bifid, entire or crenulate; perianth clavate or obovate, sharply five-keeled, the keels and sometimes the whole surface roughened from projecting cells: ♂ spike usually occupying a short branch.

1. **Trachylejeunea Oahuensis** sp. nov.

Plate LII., figs. 3–12.

Autoicous: creeping among other bryophytes, yellowish- or brownish-green: stems irregularly branched: leaves contiguous or subimbricated, the lobe widely spreading, falcate-ovate, convex, arching to about middle of axis, rounded at apex, entire or slightly crenulate from projecting cells; lobule ovate, strongly inflated, obliquely lunate at apex with a short apiculate tooth, keel strongly arched, forming approximately a right angle with the postical margin of lobe, free margin of lobule almost straight, strongly involute to beyond apical tooth, entire: underleaves distant, broadly ovate, bifid about two fifths with obtuse lobes and narrow sinus, entire, not cordate at base: leaf-cells with conspicuous trigones, papillose: ♀ inflorescence borne on a short branch, sometimes innovating on one side, sometimes without innovation; bracts unequally bifid, the lobe obovate, sometimes broadly so, truncate or rounded at apex, entire, lobule ovate to lanceolate, obtuse, entire; bracteole ovate, bifid about one sixth with obtuse lobes and narrow sinus; perianth obovate, truncate above and with a short beak, almost terete to above middle, then sharply five-keeled, the keels crenulate: ♂ spike occupying a short branch, bracts in two to five pairs, strongly concave, subequally bilobed with blunt divisions; bracteoles at base of spike small, shortly bifid with obtuse lobes, upper bracteoles wanting.

Stems 0.07^{mm} in diameter, lobes of leaves 0.4 x 0.3^{mm}, lobules 0.2 x 0.1^{mm}, underleaves 0.17 x 0.15^{mm}, cells at edge of lobe 13μ in

diameter, in the middle 23 x 18μ, and at the base, 26 x 18μ, lobe of bract 0.45 x 0.35 ^{mm}, lobule 0.35 x 0.1^{mm}, bracteole 0.35 x 0.25^{mm}, perianth 0.85 x 0.45^{mm}.

On leaves or creeping among other hepatics. Oahu : Nuuanu and Lanihuli (Cooke).

Sande-Lacoste's figures and description* of *Lejeunea decursiva* would seem to indicate that this Javan species bore a marked resemblance to the plant just described. From a specimen of the original material kindly sent me by Professor Schiffner, I find that *L. decursiva* is a *Eulejeunea*, as he has already noted,† and that it is much more branched than *Trachylejeunea Oahuensis ;* the lobes of the leaves, moreover, are more rounded, their lobules are smaller and the divisions of the underleaves are more pointed. The Hawaiian species is not nearly so rough as many members of the genus, but shows, nevertheless, distinctly papillose cells in many places, and particularly on the keels of the perianths.

12. **CHEILOLEJEUNEA** (Spruce) Schiffn.

Lejeunea subgenus *Cheilo-Lejeunea* Spruce, Hep. Amaz. et And. 251. 1884.

Cheilolejeunea Schiffn.; Engler & Prantl, Nat. Pflanzenfam. i^3, 124. 1893.

Plants small or medium-sized, whitish or pale green, sometimes tinged with brown or yellow, closely appressed to substratum, creeping among other bryophytes or growing in wide, thin mats : stems irregularly pinnately branched : leaves more or less imbricated, the lobe widely spreading, rounded at apex, entire or crenulate from projecting cells; lobule ovate to cylindrical, obliquely truncate, strongly inflated : underleaves contiguous or subimbricated, medium-sized, orbicular, bifid: leaf-cells rather thin-walled but usually with distinct trigones : ♀ inflorescence borne sometimes on a short simple branch without innovations, sometimes on a longer branch with innovations on one or both sides ; bracts and bracteoles similar to the leaves and underleaves ; perianth more or less compressed, plane or with a very low keel antically, and with a low, sometimes bluntly two-angled keel postically: ♂ spike terminal or intercalary, sometimes occupying the whole of a short branch.

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* Syn. Hep. Jav. 72. *pl. 14.* 1856.

† Conspect. Hepat. Arch. Ind. 248. 1898.

The four genera *Hygrolejeunea*, *Euosmolejeunea*, *Cheilolejeunea* and *Pycnolejeunea* are so closely allied that they might consistently be placed in a single genus. It is not only difficult to define them in a satisfactory way, but there are several species which fit in one about as well as in another. In fact, writers are apparently most uncertain as to the limits of these groups, and we find that certain species are placed in different genera by different authors or even by the same author at different times. A few illustrations of this statement may be quoted :

Lejeunea duriuscula Nees is placed by Spruce in *Cheilo-Lejeunea;** a few years afterwards Stephani, in his valuable revision of the genus *Lejeunea*,† places it in *Euosmo-Lejeunea*, and, on the very next page of the same article, puts it back into *Cheilo-Lejeunea;* in Spruce's last paper‡ he too places it in *Euosmo-Lejeunea.*

Lejeunea adnata Kunze is placed by Spruce in *Cheilo-Lejeunea* (as *L. confluens* Lindenb., a synonym)§, while Stephani places it in *Pycno-Lejeunea.*‖

Lejeunea phyllobola Mont. is placed by Spruce in *Cheilo-Lejeunea*,¶ and by Stephani in *Hygro-Lejeunea.***

Of the four species here referred to *Cheilolejeunea*, all have been found with perianths except *C. Sandvicensis.* They are very uniform in appearance, and, with the exception of *C. stenoschiza*, are all of about the same size. This species is considerably larger than the others, and apparently on account of its robustness, is placed by Herr Stephani in *Pycnolejeunea*, with which it certainly has much in common.

1. Cheilolejeunea stenoschiza (Ångstr.).

Lejeunea stenoschiza Ångstr. Öfversigt af Kongl. Vetensk. Akad. Förhand. xxix, Häft 4, 26. 1872.

Pycnolejeunea stenoschiza Steph. Bull. de l'Herb. Boissier, v, 842. 1897.

Plate LIII., figs. 1–7.

Autoicous: plants brownish-green, closely appressed to substratum and sometimes forming patches of considerable extent: stems irreg-

* Hep. Amaz. et And. 259. 1884.
† Hedwigia, xxix, 80, 81. 1890.
‡ Jour. Linn. Soc. Bot. xxx, 346. 1894.
§ Hep. Amaz. et And. 252. 1884.
‖ Hedwigia, xxix, 81. 1890.
¶ L. c. 259.
** L. c. 81.

ularly branched : leaves imbricated, the lobe convex, widely spreading, falcate-ovate, arching across axis but scarcely beyond, rounded and decurved at the apex, entire ; lobule ovate-rectangular, obliquely truncate with obtuse or acute apex, keel slightly arched, free margin almost straight as far as the apex, slightly involute toward the base, entire: underleaves contiguous or subimbricated, orbicular, not cordate but sometimes very slightly decurrent at base, attached by a short curved line of insertion, bifid one sixth to one fifth with obtuse or subacute connivent lobes and narrow sinus: leaf-cells thin-walled with small, scarcely evident trigones: ♀ inflorescence borne on a principal branch, innovating on one side, the innovation repeatedly floriferous; bracts unequally bifid, the lobe falcate-ovate, rounded at the apex, entire, lobule narrowly ovate, rounded or obtuse at the apex, entire; bracteole free, oblong, very shortly bifid (about one tenth) with subacute lobes and narrow sinus, entire; perianth about a third exserted, obovate, gradually narrowed toward the base, truncate at the apex and with a short beak, slightly compressed on sides, plane or nearly so antically and with a broad, low, two-angled keel postically: ♂ inflorescence borne on very short or slightly elongated branches, bracts in two to five pairs, imbricated, inflated, subequally bifid; bracteoles smaller than the ordinary underleaves, wanting except at base of spike.

Stem 0.1^{mm} in diameter, lobes of leaves 0.95×0.5^{mm}, lobules 0.35×0.2^{mm}, underleaves 0.5×0.5^{mm}, cells at edge of lobe 12μ in diameter, in the middle 18μ, at the base $23 \times 18\mu$, lobe of bract 0.85×0.5^{mm}, lobule 0.5×0.17^{mm}, bracteole 0.6×0.4^{mm}, perianth 1.1×0.65^{mm}.

On trees. Oahu : Nuuanu (Cooke); first collected on the island by Andersson.

An interesting feature of *Cheilolejeunea stenoschiza* is the narrow sinus of the underleaves. This is in fact so pronounced and the lobes are so strongly connivent or even overlapping, that, at first sight, the underleaves appear quite undivided. *C. Sandvicensis* resembles *C. stenoschiza* in its thin-walled leaf-cells but is amply distinct in its small and differently shaped lobules. The very common *C. intertexta*, besides being much smaller, has more deeply bifid underleaves and smaller lobules with their free margins strongly revolute. Mr. Cooke's specimens of *C. stenoschiza* agree closely with the type-material of Ångström.

2. **Cheilolejeunea intertexta** (Lindenb.) Steph.

Lejeunea intertexta Lindenb.; G. L. & N. Syn. Hep. 379. 1845.
Cheilolejeunea intertexta Steph. Bull. de l'Herb. Boissier, v, 842. 1897.

Plate LIV.

Autoicous: plants pale or yellowish-green, sometimes brownish, closely appressed to substratum or scattered among other bryophytes: stems irregularly pinnate: leaves imbricated, the lobe widely spreading, convex, broadly ovate, slightly falcate, arching across axis but scarcely beyond, rounded or very obtuse at the more or less decurved apex, entire; lobule strongly inflated, ovate, obliquely truncate or lunulate beyond the acute apex, keel slightly arched, free margin more or less involute as far as the apex: underleaves contiguous or subimbricated, orbicular, not cordate at the base, attached by a slightly curved line of insertion, bifid one fifth to one third with subacute spreading or connivent lobes and narrow sinus: leaf-cells papillose, with thin walls and small but distinct trigones: ♀ inflorescence borne on a principal branch or on a short lateral branch, innovating on one or on both sides, the innovations often again floriferous; bracts unequally bifid, the lobe falcate-oblong or obovate, rounded at the apex, entire, lobule ovate or oblong, rounded or obtuse at the apex, entire; bracteole oblong, bifid about one fourth with obtuse or subacute lobes and narrow sinus; perianth obovate, gradually narrowed toward the base, rounded at the apex and with a short beak, plane or nearly so on antical surface, and with a broad two-angled postical keel, slightly compressed on sides: ♂ spike terminal on a simple, usually short branch; bracts in two to ten pairs; bracteoles wanting except near base of spike: spores green, irregular in shape, but more or less oblong, with a thickened, whitish, minutely tuberculate wall.

Stem 0.09^{mm} in diameter, lobes of leaves 0.55 x 04^{mm}, lobule 0.17 x 0.03^{mm}, underleaves 0.3 x 0.3^{mm}, cells at edge of lobe 12μ in diameter, in the middle 17μ, at the base 20 x 17μ, lobe of bract 0.7 x 0.4^{mm}, lobule 0.35 x 0.17^{mm}, bracteole 0.5 x 0.35^{mm}, perianth 0.7 x 0.5^{mm}, spores 25μ in shortest diameter.

On trees or creeping among other bryophytes. Oahu: Panoa (Heller); Nuuanu (Heller, Cooke). Kauai: Kipu (Cooke).

The determination of the present species is based on a plant in Mr. Heller's collection, named by Herr Stephani. In a sterile condition, *Cheilolejeunea intertexta* closely resembles several South American species, named and distributed by Spruce, and among these, more

particularly, *C. roseoalba* and *C. heteroclada.* Both of these species differ in the ♀ inflorescence, which is not subtended by an innovation; *C. heteroclada* is moreover dioicous. Judging from Mr. Cooke's collections, *C. intertexta* is one of the commonest Lejeuneæ on the Islands.

3. **Cheilolejeunea Hawaica** Steph.

Cheilolejeunea Hawaica Steph. Bull. de l'Herb. Boissier, v, 847. 1897.

Plate LIII., figs. 8–14.

Autoicous: plants yellowish-brown, creeping among mosses: stems irregularly pinnately branched: leaves contiguous or subimbricated, the lobe widely spreading, falcate-obovate from a narrow base, arching to about the middle of axis, rounded at the apex, entire; lobule inflated, ovate or triangular-ovate, obliquely truncate with acute apex, keel straight or slightly curved, free margin appressed to lobe except toward base, where it is involute, entire: underleaves distant, orbicular, not cordate, attached by a slightly curved line of insertion, bifid one third to one half with acute or obtuse lobes and narrow sinus: leaf-cells with large trigones and occasional intermediate thickenings, often confluent: ♀ inflorescence borne on a principal branch, innovating on one side with a short simple innovation; bracts unequally bifid, the lobe falcate-ovate, rounded at the apex, entire, lobule linear to oblong, rounded or obtuse, entire; bracteole free, oblong, bifid about one fourth with subacute or obtuse lobes and narrow sinus; perianth obovate or cuneiform, gradually narrowed toward the base, truncate at the apex and with a short beak, somewhat compressed on sides, antical surface plane, postical surface with a broad two-angled keel: ♂ inflorescence intercalary or terminal, often on a large branch: bracts in five or six pairs.

Stems 0.08^{mm} in diameter, lobes of leaves 0.55 x 0.35^{mm}, lobules 0.15 x 0.1^{mm}, underleaves 0.2 x 0.2^{mm}, cells at edge of lobe 8μ in diameter, in the middle 16μ and at the base 27 x 18μ, lobe of bract 0.6 x 0.4^{mm}, lobule 0.35 x 0.17^{mm}, bracteole 0.6 x 0.35^{mm}, perianth 0.85 x 0.6^{mm}.

Creeping among mosses. Hawaii? (Baldwin). Oahu: Konahuanui (Cooke).

The description given above is drawn partly from the original specimens, kindly sent me by Herr Stephani, partly from the published description of that author and partly from specimens collected

last summer by Mr. Cooke. The type-locality, Hawaii, is probably incorrect, as Mr. Baldwin did nearly all of his collecting on Maui.

C. Hawaica may be at once distinguished from the other Hawaiian species by its distant underleaves and thick-walled leaf-cells. In these respects it somewhat resembles *Trachylejeunea Oahuensis*, a smaller plant with a larger lobule, the keel of which is almost at right angles with the postical margin of the lobe, instead of forming a very obtuse angle with it as in the present species. *C. Hawaica* finds a rather close ally in the South American *C. aneogyna* (Spruce), but differs from this species in having subfloral innovations.

4. **Cheilolejeunea Sandvicensis** Steph.

Lejeunea cancellata Mont. Ann. des Sc. Nat. II, xix, 262. 1843 (in part).

Lejeunea (*Cheilo-Lejeunea*) *Sandvicensis* Steph. Hedwigia, xxix, 88. 1890.

Lejeunea subligulata Evans, Trans. Conn. Acad. viii, 254. 1891.

Cheilolejeunea Sandvicensis Steph. Bull. de l'Herb. Boissier, v, 842. 1897.

Sterile: medium-sized, dull green: stems robust, pinnately branched, the branches spreading at almost a right angle: leaves slightly imbricated, the lobe widely spreading, ovate-ligulate, rotund at apex, entire; lobule small, subtriangular, strongly narrowed from a broad base, obliquely truncate beyond the acute apex, keel somewhat arched, free margin strongly involute at base, entire: underleaves distant, or bicular, bifid about two fifths with subacute, distant lobes and obtuse or lunulate sinus: leaf-cells thin-walled and without trigones.

Stems 0.12^{mm} in diameter, lobes of leaves 0.9 x 0.6^{mm}, lobule 0.15 x 0.12^{mm}, underleaves 0.25 x 0.25^{mm}, leaf-cells at edge of lobe 8μ in diameter, in the middle 17μ, at the base 35 x 17μ.

Hawaiian Islands (Gaudichaud).

I have seen no specimens of this species and my description is largely translated from the original one, a few details being added from a drawing kindly sent me by Herr Stephani. Descriptions of the male and female inflorescences of *L. cancellata* are given by Montagne, but, as it may be questioned whether these really apply to Stephani's plant, I have omitted them from my diagnosis. *C. Sandvicensis* is apparently almost as robust as *C. stenoschiza*, which it resembles also in its thin-walled leaf-cells; it is, however, amply

distinct in its small, distant, and more deeply bifid underleaves, and in its much smaller and differently shaped lobules.

13. **LEJEUNEA** Libert.

Lejeunea Libert, Ann. Gen. des Sci. Phys. (Bruxelles) vi, 372. 1820 (in part).

Lejeunea subgenus *Eu-Lejeunea* Spruce, Hep. Amaz. et And. 260. 1884.

Eulejeunea subgenus *Eulejeunea* sensu str. Schiffn.; Engler & Prantl, Nat. Pflanzenfam. i^3, 122. 1893.

Plants small or medium-sized, pale or bright green, sometimes yellowish, adhering to substratum or forming thin mats: stems irregularly pinnate: leaves contiguous or slightly imbricated, the lobe widely spreading, ovate to obovate, rounded or obtuse at apex, entire or slightly crenulate from projecting cells; lobule small, sometimes obsolete, inflated or plane: underleaves distant, small or medium-sized, bifid: leaf-cells transparent, thin-walled, though sometimes with small trigones: ♀ inflorescence borne on a principal branch, innovating on one or on both sides; bracts and bracteoles similar to the leaves and underleaves; perianth with five sharp keels, one antical, two lateral and two postical, not compressed: ♂ spike usually occupying a short lateral branch.

Of the genus *Lejeunea* in its restricted sense, only two species, *L. anisophylla* and *L. Pacifica*, are definitely known from the Hawaiian Islands. My determination of *L. Pacifica* is based on the original description of Montagne, supplemented by a drawing of the type-specimen, which I owe to the kindness of Herr Stephani. The specimens referred to *L. anisophylla* agree with a portion of the type-material preserved in the Gottsche Herbarium at Berlin.

1. **Lejeunea anisophylla** Mont.

Lejeunea anisophylla Mont. Ann. des Sc. Nat. II, xix, 263. 1843.

Plate LV., figs. 8–15.

Autoicous: plants bright or pale green, closely appressed to substratum or growing in small thin mats: stems irregularly pinnate: leaves imbricated, the lobe arching to or beyond the middle of the axis, ovate, rounded or very obtuse at the apex, entire; lobule ovate from a broad base, obliquely truncate at the subacute apex, keel slightly arched, free margin strongly involute almost to the apex:

underleaves orbicular, bifid about one half with subacute lobes and lunulate sinus, entire or slightly crenulate from projecting cells: leaf-cells with small, indistinct, and often confluent trigones and intermediate thickenings: ♀ inflorescence borne on a principal branch, innovating on one side, the innovation sometimes floriferous but usually short and sterile; bracts deeply bifid, the lobe ovate or oblong, rounded or obtuse at the apex, entire or slightly crenulate, lobule lanceolate to narrowly oblong, acute to rounded at the apex, crenulate; bracteole obovate from a narrow base, slightly connate on one side, bifid about one half with acute lobes and narrow sinus, slightly crenulate or angular-unidentate on sides; perianth obovate, cuneate toward base, truncate above and with a short beak, antical keel low, the others sharp, keels entire or slightly crenulate on the edges: ♂ inflorescence occupying a short branch or terminal on a longer one, bracts in three to five pairs, subequally bifid, with broad, rounded lobes; bracteoles confined to base of spike, small, bifid one half with acute spreading lobes and narrow sinus: spores green, oblong with a rather thin whitish wall, minutely tuberculate.

Stems 0.1^{mm} in diameter, lobes of leaves 0.6 x 0.45^{mm}, lobules 0.16 x 0.13^{mm}, underleaves 0.25 x 0.25^{mm}, cells at edge of lobe 16μ in diameter, in the middle 20μ, at the base 31 x 23μ, lobe of bract 0.5 x 0.25^{mm}, lobule 0.45 x 0.08^{mm}, bracteole 0.45 x 0.25^{mm}, perianth 0.7 x 0.5^{mm}, spores 15μ in shortest diameter.

On bark and leaves. Oahu: Nuuanu (Cooke). Kauai: Kipu, Lihue, Molokoa (Cooke). Hawaiian Islands (Gaudichaud).

2. **Lejeunea Pacifica** Mont.

Lejeunea Pacifica Mont. Ann. des Sc. Nat. II, xix, 262. 1843.
Eulejeunea Pacifica Steph. Bull. de l'Herb. Boissier, v, 842. 1897.

Plate LV., figs. 1–7.

Autoicous or dioicous: plants pale green, closely appressed to substratum: stems irregularly pinnate: leaves distant to subimbricated, the lobe ovate to obovate, not arching across stem but forming almost a straight line above the base, rounded at the apex, entire or very slightly crenulate; lobule triangular-ovate, obliquely truncate beyond the apiculate apex, keel almost straight, continuous with postical margin of lobe, free margin strongly involute near the base, entire; lobule often poorly developed: underleaves small, distant, bifid beyond the middle with narrow subulate lobes and broad lunulate sinus, entire or nearly so: leaf-cells thin-walled, without trigones: ♀ inflorescence borne on a principal branch or on a short lateral branch,

innovating on one side or not at all, the innovation sterile or once floriferous ; bracts unequally bifid, the lobe narrow at the base, ovate or obovate, rounded to subacute at the apex, entire or slightly crenulate, lobule lanceolate to ovate, acute or obtuse ; bracteole free, obovate from a narrow base, bifid one half with acute lobes and sinus, entire or slightly crenulate ; perianth cuneiform, gradually narrowed toward the base, broad and emarginate at the apex and with a short beak, antical keel low, lateral and postical keels sharp, slightly crenulate: ♂ inflorescence borne on a short lateral branch, bracts in three to five pairs, imbricated, subequally bifid with rounded, crenulate lobes ; bracteole at base of branch bifid about one half with acute lobes and sinus, other bracteoles wanting: spores green, oblong, with a rather thin, whitish, minutely tuberculate wall.

Stems 0.07^{mm} in diameter, lobes of leaves 0.5 x 0.35^{mm}, lobules 0.14 x 0.12^{mm}, underleaves 0.15 x 0.1^{mm}, cells at edge of lobe 17μ in diameter, in the middle 26 x 20μ, at the base 31 x 23μ, lobe of bract 0.55 x 0.3^{mm}, lobule 0.45 x 0.1^{mm}, bracteole 0.35 x 0.2^{mm}, perianth 0.7 x 0.4^{mm}, spores 12μ in shortest diameter.

On leaves and bark. Oahu : Nuuanu (Cooke); also collected by Andersson. Hawaiian Islands (Gaudichaud).

The peculiar shape of the perianth places this delicate little plant in Dr. Spruce's section "*Cardianthæ*," which includes half a dozen South American species. Among these, *L. drymophila* comes very close to *L. Pacifica :* it differs in its leaf-cells, which, although equally thin-walled, have minute but distinct trigones ; and in the shape of its perianth, which narrows more abruptly towards the base.

In a sterile condition, *L. Pacifica* is much like *L. anisophylla*, resembling it in size, in color, and in the shape of its leaves. In *L. anisophylla*, however, the keel of the lobule forms an obtuse angle with the postical margin of the lobe instead of an almost straight line, and the leaf-cells have small trigones and intermediate thickenings. In fertile plants, the very different perianths will at once serve to separate the two species.

14. **MICROLEJEUNEA** (Spruce) Jack & Steph.

Lejeunea subgenus *Micro-Lejeunea* Spruce, Hep. Amaz. et And. 286. 1884 (in part).

Eulejeunea subgenus *Microlejeunea* Schiffn.; Engler & Prantl, Nat. Pflanzenfam. i^{3}, 124. 1893.

Microlejeunea Jack & Steph. Bot. Centralbl. lx, 11. 1894 (reprint).

Plants very small, green or whitish-green, creeping over other bryophytes or closely appressed to substratum and sometimes forming

small flat mats: stems sparingly branched: leaves distant to subimbricated, the lobe slightly spreading or subparallel with stem, rounded to subacute at apex, entire or slightly crenulate; lobule more than half the size of lobe, inflated: underleaves distant and small, bifid: leaf-cells small, thick-walled: ♀ inflorescence borne on a principal branch or on a short lateral branch, innovating on one or, rarely, on both sides; bracts and bracteoles larger than the leaves and underleaves, but similar; perianth with five sharp, smooth keels: ♂ inflorescence occupying a short branch or terminal on a longer one.

The genus *Microlejeunea*, as thus restricted by Jack & Stephani, is represented on the Hawaiian Islands by a very common species, which has been repeatedly referred to *Lejeunea cucullata* Nees. Herr Stephani has pointed out, however, that this old species, as represented in the Lindenberg Herbarium, is composite and is made up of no less than six perfectly distinct plants.* He at first advised that the name "*cucullata*" be given up altogether, but has since restricted it to a plant from Java, the original locality of the species,† and the name is also used by Schiffner in a somewhat similar sense.‡ Stephani refers the Hawaiian plant to *Lejeunea albicans* Nees, a species first collected on the Philippine Islands. In the Gottsche Herbarium at Berlin there is a specimen of this species from Manila, which closely agrees with the Hawaiian plant, and the same is true of a specimen from Luzon in the herbarium at Kew. There is also at Kew a plant from Java, determined as *L. cucullata* by Stephani, which is evidently something quite distinct. The Hawaiian specimens in the Gottsche Herbarium, finally, which are labeled *L. cucullata* are the same as the common species and therefore agree with *L. albicans* and not with the true *L. cucullata*, as represented by this specimen at Kew. In view of these facts, I feel justified in excluding *L. cucullata* from the list of Hawaiian plants and in applying to their common *Microlejeunea* the name *M. albicans*. Herr Stephani§ has recently ascribed a second species, *M. erectifolia* (Spruce) Steph. to the Islands, but I have been unable to distinguish it.

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* Hedwigia, xxix, 89. 1890.

† Jack & Steph. Bot. Centralbl. lx, 10. 1894 (reprint).

‡ Conspect. Hepat. Arch. Ind. 253. 1898.

§ Bull. de l'Herb. Boissier, v, 842. 1897.

1. **Microlejeunea albicans** (Nees) Steph.

Lejeunea cucullata Auct. (not *Jungermannia cucullata* R. Bl. & Nees).

Lejeunea cucullata γ parasita G. L. & N. Nova Acta Acad. Leop.-Car. xix, suppl. 1, 473. 1843.

Lejeunea albicans Nees ; G. L. & N. Syn. Hep. 387. 1845.

Micro-Lejeunea albicans Steph. Hedwigia, xxix, 88. 1890; Jack & Steph. Bot. Centralbl. lx, 10. 1894 (reprint).

Plate LVI., figs. 1–5.

Autoicous: plants pale or bright green, closely appressed to substratum, sometimes occurring in wide, thin mats: stems irregularly pinnate: leaves distant to subimbricated, the lobe slightly spreading or almost erect, ovate, reaching to about the middle of axis, rounded at the apex, entire ; lobule strongly inflated, ovate, obliquely truncate or excavate beyond the apiculate apex, the apical tooth composed of one or two cells, keel strongly arched, crenulate, free margin strongly involute as far as apical tooth : underleaves distant, orbicular, bifid about one half with obtuse or subacute lobes and narrow sinus : leaf-cells papillose, pretty uniformly thickened and without distinct trigones : ♀ inflorescence borne on a short lateral branch or on a principal branch, innovating on one or, rarely, on both sides, the innovation usually floriferous ; bracts unequally bifid, the lobe obovate, rounded at the apex, the lobule lanceolate and subacute, both entire ; bracteole slightly connate on one side, obovate from a narrow, cuneate base, shortly bifid (about one tenth) with obtuse or subacute lobes and acute sinus, entire or obscurely angular-unidentate on sides ; perianth obovate, gradually narrowed toward base, truncate above and with a short beak, antical keel low, the others sharp : ♂ inflorescence occupying a short lateral branch, bracts in two to five pairs, imbricated, subequally bifid with rounded lobes ; bracteole at base of spike small, orbicular, bifid, the others wanting : spores green, oblong, with a thick, white, minutely tuberculate wall.

Stems 0.04^{mm} in diameter, lobes of leaves 0.25 x 0.15^{mm}, lobules 0.17 x 0.1^{mm}, underleaves 0.08 x 0.08^{mm}, cells at edge of lobe 9μ in diameter, in the middle 12μ, at the base 23 x 12μ, lobe of bract 0.35 x 0.2^{mm}, lobule 0.3 x 0.08^{mm}, bracteole 0.4 x 0.25^{mm}, perianth 0.6 x 0.35^{mm}, spores 25μ in shortest diameter.

On trees. Oahu : Nuuanu, Mt. Tantalus (Cooke); also collected by Didrichsen and by Meyen. Kauai : Kilohana (Cooke). Hawaii Kilauea (Didrichsen); also collected by Remy.

A very close ally, apparently, of *M. albicans* is *M. crassitexta*, described by Jack and Stephani from sterile specimens collected on the Fiji Islands. This species differs, however, in its more deeply cleft underleaves. The true *M. cucullata* has ovate, long-decurrent underleaves and differently shaped leaves.

15. COLOLEJEUNEA (Spruce) Schiffn.

Lejeunea subgenus *Colo-Lejeunea* Spruce, Hep. Amaz. et And. 291. 1884.

Cololejeunea Schiffn.; Engler & Prantl, Nat. Pflanzenfam. i^3, 121: 1893.

Plants variable in habit, very small to medium-sized, pale green varying to brownish-green: leaves attached by a very narrow base, the lobe widely spreading, rounded to subacute at the apex, entire, crenulate, or denticulate, lobule inflated or plane, very variable in shape; stylus present, sometimes reduced to a single cell: underleaves absent, in their place clusters of rhizoids, one for each leaf: leaf-cells mostly thin-walled, often papillose: ♀ inflorescence terminal on a principal branch or on a short branch, innovating on one side, the innovation often floriferous; bracts similar to the leaves; perianth very variable: ♂ inflorescence occupying a short branch or terminal, sometimes on the main axis.

According to our present knowledge, *Cololejeunea* is represented by more Hawaiian species than any other genus of the Lejeuneeæ, and it is probable that many interesting forms still remain undiscovered. The majority of the species are small and some of them are very small, and this fact, together with the epiphyllous habit of most of the tropical species, sometimes makes the plants difficult of detection. Of the seven Hawaiian species, six belong in Dr. Spruce's section *Leptocolea*, which is exclusively tropical, while the seventh species, *C. Cookei*, represents his section *Physocolea*, which is found in both tropical and temperate regions. These two sections are almost of generic importance. Most of the Hawaiian species show the disc-shaped gemmæ, whose structure and development has been fully described by Goebel.*

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* Ann. du Jard. Bot. de Buitenzorg, vii, 49ff. 1888.

I. Subgenus Physocolea (Spruce) Schiffn.

1. **Cololejeunea Cookei** sp. nov.

Plate LVI., figs. 6–14.

Autoicous : plants green or brownish-green, growing in loose thin mats : stems irregularly branched : leaves distant, the lobe broadly ovate, squarrose, attached to the axis by a very narrow base, rounded or very obtuse at the apex, crenulate from projecting cells; lobule ovate, plane or somewhat inflated, keels strongly arched, crenulate, free margin plane throughout or slightly involute at base, ending in a blunt tooth and bearing between this and the end of the keel a second tooth composed of two cells, crenulation less marked than on the lobe ; stylus a single cell, often obsolete: leaf-cells papillose, thin-walled and without trigones : ♀ inflorescence borne on a principal branch, innovating on one side, the innovation inserted at or above the level of the opposite bract, long, not immediately floriferous ; bracts at different levels, slightly bifid, the lobe and lobule rounded or very obtuse at the apex, crenulate ; perianth obovate from a narrow, often stalk-like base, rounded above and narrowed into a short beak, sharply five-keeled (one antical, two lateral and two postical), the keels slightly crenulate : ♂ inflorescence terminal on a principal branch, large for the size of the plant ; bracts in ten or more pairs, closely imbricated, subequally bifid ; antheridia two in each axil : spores more or less oblong in shape, greenish, with a rather thick, yellowish, minutely tuberculate wall.

Stem 0.05^{mm} in diameter, leaf-lobes 0.25 x 0.2^{mm}, leaf-lobules, 0.18 x 0.1^{mm}, cells at edge and in the middle of lobe 16μ in diameter, at the base 18μ, lobe of bract 0.4 x 0.15^{mm}, lobule 0.35 x 0.1^{mm}, perianth 0.6 x 0.35^{mm}, spores 25μ in shortest diameter.

On bark of trees. Kauai : Molokoa, Kipu (Cooke).

Cololejeunea Cookei may be at once distinguished from all the other Hawaiian species by its minute size, its more or less squarrose leaves, its proportionately large lobule, which is often three fourths as long as the lobe, its crenulate leaf-margins and its sharply five-keeled perianth. A much nearer relative is the well-known *C. minutissima* (Sm.) Schiffn. of Europe and the southern United States. This species is, however, a little larger and has larger leaf-cells ; its perichætial bracts are subopposite and the innovation is usually below the opposite bract ; the male spike is smaller and is situated on a small lateral branch. According to Spruce*, the ♂ bracts of *C.*

* Hep. Amaz. et And. 293. 1884.

minutissima are monandrous, but this character, which might seem an excellent differential one, is not constant, as, in an Italian specimen collected by the author, the bracts are distinctly diandrous.

II. Subgenus Leptocolea (Spruce) Schiffn.

2. Cololejeunea obcordata (Aust.).

Lejeunea obcordata Aust. Bot. Gazette, i, 36. 1876.

Plate LVII., figs. 1–6.

Autoicous: plants yellowish-green, creeping about in tufts of other bryophytes: stems irregularly pinnately branched: leaves contiguous or subimbricated, the lobe widely spreading, ovate from a very narrow base, rounded at the apex, subentire or indistinctly crenulate and angular-dentate, antical margin curved, postical margin almost straight; lobule inflated, ovate, keel slightly arched, free margin involute and entire near the base, rounded above and bearing two or three small teeth; stylus a single cell, often obsolete: leaf-cells with thickened walls, trigones and intermediate thickenings conspicuous and often confluent: ♀ inflorescence borne on a very short branch, innovating on one side with a short sterile innovation; bracts bifid, the lobule a little smaller than the lobe, both divisions ovate to oblong, rounded at the apex, subentire; perianth cuneiform, deeply emarginate and with a short and very indistinct beak at bottom of depression, strongly compressed, the two lateral keels extending upwards as widely spreading, rounded and more or less denticulate projections, antical surface plane, postical surface with a broad, low keel, both surfaces smooth: ♂ spike occupying a short branch, globose to oval, bracts in one to three pairs, imbricated, strongly inflated, unequally bifid with entire lobes.

Stems 0.05^{mm} in diameter, lobes of leaves 0.55 x 0.35^{mm}, lobules 0.2 x 0.15^{mm}, cells at edge of leaf 20μ in diameter, in the middle and at the base 25μ, lobe of bract (a) 0.5 x 0.3^{mm}, (b) 0.35 x 0.25^{mm}, lobule (a) 0.45 x 0.3^{mm}, (b) 0.3 x 0.2^{mm}, perianth 0.8^{mm} long, 0.7^{mm} wide in broadest part.

Creeping among other bryophytes. Oahu: Konahuanui (Cooke). Austin simply refers the plant to the "Sandwich Islands" and does not give the collector's name.

Cololejeunea obcordata, although closely allied to the following species, may be at once distinguished from it by its firmer texture, the leaf-cells having thick walls and very conspicuous trigones, by the position of the ♀ inflorescence and by the widely divaricate lobes

of the perianth, which are usually dentate and not crenulate on the margin.

3. **Cololejeunea ceatocarpa** (Ångstr.) Steph.

Lejeunea ceatocarpa Ångstr. Öfversigt af Kongl. Vetensk. Akad. Förhand. xxix, Häft 4, 27. 1872.

Cololejeunea ceatocarpa Steph. Bull. de l'Herb. Boissier, v, 842. 1897.

Plate LVII., figs. 7–13.

Autoicous: plants pale green, creeping, sometimes forming thin patches of considerable size: stems irregularly pinnate: leaves distant or contiguous, the lobe widely spreading, oblong from a very narrow base, antical margin more curved than postical, rounded at the apex, entire or minutely denticulate at apex; lobule ovate, more or less inflated at least toward base, keel slightly arched, free margin slightly involute near the base, elsewhere appressed to the lobe, bearing a rounded tooth a little beyond the middle, then obliquely truncate and with a small apiculum between the tooth and the end of keel; stylus a single cell, often obsolete: leaf-cells thin-walled with small and very indistinct trigones, marginal cells near apex sometimes with angular outer walls forming minute, blunt teeth: ♀ inflorescence borne on a principal branch, innovating on one side, usually once floriferous; bracts unequally bifid, the lobe and lobule obovate, rounded at the apex, entire or the lobe usually slightly denticulate at the apex from projecting cells, the lobule with an apiculate tooth on the edge; perianth obovate, compressed, gradually narrowed toward base, obcordate at apex and bearing a short beak at bottom of depression, antical surface plane, postical keel low, cells in upper part, especially on keels, papillose, making the perianth appear denticulate on the edge: ♂ spike terminal on a principal branch or occupying a short branch, bracts in five to ten pairs, smaller than the leaves, imbricated, lobe and lobule subequal in size at least toward apex of spike, entire or slightly denticulate; antheridia two in each axil.

Stem 0.05^{mm} in diameter, lobes of leaves 0.6 x 0.35^{mm}, lobules 0.25 x 0.15^{mm}, cells at edge of leaf 19μ in diameter, in the middle 21μ, at the base 40 x 18μ, lobe of bract 0.65 x 0.2^{mm}, lobule 0.35 x 0.12^{mm}, perianth 0.7 x 0.4^{mm}.

On leaves or, more rarely, on bark. Oahu: Nuuanu (Cooke); first collected on the island by Andersson. Kauai: Hanapepe Falls (Heller).

C. ceatocarpa is apparently the commonest *Cololejeunea* on the Islands. It sometimes grows in company with *C. lanciloba* (as in Heller's specimens), but can be separated from this species even when dry from the fact that its leaves do not adhere closely to the substratum. More closely allied to it than any of the other Hawaiian species are *C. erigens* Spruce* of South America and *C. Goebelii* (Gottsche) Schiffn.† of the East Indies. In the first, the leaves are narrower and more obliquely spreading and show curious bluntly conical papillæ on the cells, particularly those at and near the apex. The papillæ project at right angles to the surface of the leaf and not beyond the margin, as do the differently shaped marginal papillæ sometimes formed on the leaves of the Hawaiian plant. The East Indian species is still closer to *C. ceatocarpa* and may prove to be identical with it: the marginal denticulations or crenulations in this species are, however, always present (although in Schiffner's var. *Acrotremæ* they are very scanty) and are scattered along the whole margin, instead of being confined to the apical region. The ♂ bracts also are described as semiglobose, where as in *C. ceatocarpa*, they are more like the ordinary leaves. The specimens collected by Cooke and by Heller agree closely with Ångström's type.

4. Cololejeunea ovalifolia sp. nov.

Plate LVIII., figs. 1–6.

Dioicous: brownish-green (at least when dry), closely adherent to substratum: stems irregularly pinnate: leaves distant, the lobe oval or ovate, rounded at the very narrow base and at the apex, entire; lobule oval, inflated at the base, keel arched, free margin more or less involute in lower part, ending in a blunt apex, then obliquely truncate and bearing a small tooth tipped with a papilla between apex and end of keel, lobule often much reduced; stylus a single cell, often obsolete: leaf-cells thin-walled, without trigones: ♀ inflorescence borne on a principal branch, innovating on one side, the innovation often floriferous; bracts unequally bifid, the lobe obovate, rounded at the apex, entire, lobule very narrow at the base, broader and apiculate at the apex, entire or bearing two or three blunt teeth formed from projecting cells; perianth obovate or cuneiform, not

* *Lejeunea obliqua* Spruce, Hep. Amaz. et And. 298. 1884 (not Mont.).
Lejeunea erigens Spruce, l. c. (as synonym).
Cololejeunea erigens Spruce, Hep. Spruceanæ. 1892 (exsic).

† Nova Acta Acad. Caes.-Leop. lx, 240. *pl. 10. f. 1–10.* 1893.

compressed, with a short beak, antical surface plane, postical surface with two sharp keels in upper part, the keels (lateral and postical) ending in subacute points or horns, cells in upper part of perianth with more or less projecting walls especially on the keels, making the latter appear slightly crenulate : ♂ inflorescence terminal on a principal branch or occupying a short lateral branch ; bracts in three to eight pairs, slightly imbricated, subequally bilobed (at least near the end of the spike) ; antheridia two in each axil.

Stem 0.05^{mm} in diameter, leaf-lobes 0.5 x 0.35^{mm}, lobules 0.15 x 0.1^{mm}, cells at edge of lobe 17μ in diameter, in the middle 21μ, at the base 23μ, lobe of bract 0.45 x 0.15^{mm}, lobule 0.15 x 0.05^{mm}, perianth 0.5 x 0.35^{mm}.

On leaves. Oahu : Nuuanu (Cooke).

The specimens of this plant have so far been found only in company with *C. ceatocarpa.* It is smaller than this species and darker in color, its leaves are shorter, and their lobules are much smaller and more inconspicuous. The most striking differences, however, are to be found in the perianths : in *C. ovalifolia* this organ is not flattened and its four keels run out into four sharp horns ; in *C. ceatocarpa*, the perianth is much flattened and obcordate at the apex. There is little danger of confusing the present plant with any of the other Hawaiian species.

5. **Cololejeunea Hillebrandii** (Aust.) Steph.

Lejeunea longifolia Aust. Bull. Torr. Bot. Club, v, 17. 1874 (not Mitt.).

Lejeunea Hillebrandii Aust. Bot. Gazette, i, 35. 1876.

Cololejeunea Hillebrandii Steph. Bull. de l'Herb. Boissier, v, 842. 1897.

Plate LVIII., figs. 7–11.

Dioicous : pale or whitish-green, closely creeping : stems irregularly branched : leaves distant, the lobe widely spreading, ovate to lanceolate, gradually narrowed into an acute, obtuse or rounded apex, entire ; lobule ovate, inflated at least toward base, keel arched, free margin appressed to lobe, curved toward base, bearing an obtuse tooth at about the middle, obliquely lunulate beyond, and with a small tooth in the middle of the lunation ; stylus a single cell, often obsolete : leaf-cells more or less elongated, at least toward middle and base of lobe, thin-walled and without trigones : ♀ inflorescence borne on a principal branch, innovating on one side (or rarely on both), the innovation once floriferous ; lobe of bracts similar to that

of normal leaves, lobule attached by an almost straight keel, oblong in shape, with a papilla near the free upper angle and a second one on the inner edge near the apex ; perianth obovate, truncate or rounded above, and narrowed into a very short beak, subterete (without distinct keels), smooth: ♂ inflorescence terminal on a principal branch or occupying a short branch, bracts in three to six pairs, contiguous or subimbricated, sometimes scarcely different from the leaves in shape, sometimes subequally bifid ; antheridia two in each axil.

Stem 0.08^{mm} in diameter, lobes of leaves 0.85 x 0.25^{mm}, lobules 0.35 x 0.15^{mm}, cells at edge of lobe 35 x 18μ, in the middle 30 x 16μ, at the base 37 x 14μ, lobe of bract 0.7 x 0.2^{mm}, lobule 0.25 x 0.05^{mm}, perianth 0.6 x 0.25^{mm}.

On *Dumortiera* and also on leaves. Hawaiian Islands (Hillebrand). Oahu : Konahuanui (Cooke).

The present species is known only from the type-material in the Austin Herbarium and from a few fragmentary specimens collected last summer by Mr. Cooke. A part of the type was kindly sent me by Mr. Pearson, and has served for the above description. The leaf-cells of *C. Hillebrandii* are variable in shape; sometimes they are elongated as in the ones whose measurements are given, sometimes they are more nearly isodiametric. In comparing this plant with other Hawaiian species, its closest ally seems to be *C. ceatocarpa*. Even in a sterile condition, however, the difference in the shape of the leaves at once suffices to distinguish them : in *C. Hillebrandii*, the lobes narrow very much toward the apex, and the broadest part is just above the base ; in *C. ceatocarpa*, the lobes are broad at the apex, and the broadest part is nearer the middle. The perianths of *C. Hillebrandii* are very scanty in the plants examined and are apparently not perfectly developed. It can be made out, however, that they are scarcely if at all flattened, and that they show no signs of anything like projections or cordations at the apex. They would, therefore, afford important differential characters for the two species.

6. Cololejeunea lanciloba Steph.

Cololejeunea lanciloba Steph. Hedwigia, xxxiv, 250. 1895.

Plate LIX., figs. 1–7.

Autoicous : plants green, closely appressed to substratum, sometimes forming patches of considerable size : leaves slightly imbricated, the lobe plane, obliquely spreading, arching beyond axis and rounded at the very narrow, almost transverse base, oval, rounded at

the apex, hyaline-margined except near the base, margin entire, almost straight at postical base ; lobule plane, subulate from a narrow base, acute or obtuse, bearing a short tooth below the middle of the inner edge, otherwise entire or nearly so, keel short, straight, almost at right angles with axis ; stylus a single cell, often obsolete: leaf-cells with small trigones and occasional intermediate thickenings; hyaline marginal cells in one or two rows at the apex, in one row elsewhere, thin-walled : ♀ inflorescence borne on a short branch with smaller leaves than the main axis, innovating on one side, the innovation usually once or twice floriferous; bracts very deeply and unequally bifid, the lobe elliptical, rounded at the apex, entire, hyaline-margined at and near the apex, lobule elliptical, rounded, truncate or emarginate at the apex, entire or with a blunt tooth near the middle of the inner edge; perianth obovate, gradually narrowed toward base, truncate and emarginate at the apex, and with a short broad beak, plane on antical surface, and with a low postical keel, smooth : ♂ inflorescence terminating a branch ; bracts in five to ten or more pairs, closely imbricated, lobe attached to lobule by an arched keel about half as long as bract ; lobule inflated, with its free margin strongly involute ; antheridia two in the axil of each bract.

Stem 0.07^{mm} in diameter, lobes of leaves (on robust axis) 0.95 x 0.65^{mm}, lobules 0.3 x 0.1^{mm}, leaf-cells just within hyaline margin of lobe 12μ in diameter, in the middle 15μ, at the base 32 x 17μ, lobe of bract 0.7 x 0.3^{mm}, lobule 0.35 x 0.15^{mm}, perianth 0.75 x 0.5^{mm}.

On leaves of *Eugenia Malaccensis*. Kauai : Hanapepe River (Heller). Oahu : Nuuanu (Cooke).

Cololejeunea lanciloba is the largest Hawaiian representative of the genus. In common with *C. longistylis*, the lobes of its leaves are hyaline-margined, but it is readily distinguished from that species and from all the others known from the Islands, by its remarkable, plane and narrow lobules. The species was first described from specimens collected on the Nicobar Islands.

7. Cololejeunea longistylis sp. nov.

Plate LIX., figs. 8–16.

Sterile : pale green, closely appressed to substratum : stems irregularly branched : leaves imbricated, the lobe obliquely spreading, ovate-oblong, rounded and hyaline-margined at the apex, entire, antical margin slightly curved, postical margin almost straight ; lobule inflated, ovate, keel cordate at the base, then almost straight and con-

tinuous with postical margin of lobe, free margin of lobule slightly involute near base, bearing an obtuse tooth ending in a single cell at about the middle, and between this and the end of the keel, bearing a larger, broad, obtuse or subacute tooth; stylus three to six cells long, often two cells broad at and near the middle: leaf-cells thin-walled, hyaline cells at apex in one to three rows.

Stem 0.08 in diameter; lobes of leaves 0.6 x 0.35^{mm}, lobules 0.25 x 0.2^{mm}, cells at edge of lobe 14μ, in the middle 17μ, at the base 26 x 14μ.

On bark of *Aleurites Mollucana*. Oahu: Nuuanu (Cooke).

Cololejeunea longistylis is at present known from sterile material only, but it is so different from the other Hawaiian species that it can be easily and surely distinguished. It resembles *C. lanciloba* in having hyaline marginal cells, but these are limited to the apical region of the lobe; in general appearance too it approaches *C. ceatocarpa*, but in this species the leaves are widely spreading and the lobule is different in shape; the most important character, however, which distinguishes it not only from these two species, but from all the others, is the multicellular stylus. A very close ally of *C. longistylis* is *C. stylosa* (Steph.)*, from the island of Luzon. This plant has likewise hyaline cells at the apex of the lobe and a multicellular stylus, but its leaf-lobes spread more widely and are more pointed and the lobules are very different in shape. *C. stylosa* is also known in sterile condition only.

16. **COLUROLEJEUNEA** (Spruce) Schiffn.

Colura Dumort. Recueil d'obs. sur les Jung. 12. 1835. (not *Coluria* R. Br.).

Lejeunea subgenus *Coluro-Lejeunea* Spruce, Hep. Amaz. et And. 303. 1884.

Colurolejeunea Schiffn.; Engler & Prantl, Nat. Pflanzenfam. i^3, 121. 1893.

Plants small, pale or yellowish-green, scattered or forming small tufts: stems irregularly pinnate, closely appressed to substratum: leaves ascending, squarrose, attached by a very narrow base and ending in a variously shaped hollow sac, derived from the lobe† and in many cases closed by a valvular arrangement; lobule small, margin strongly involute and enclosing a canal leading to the apical sac: underleaves doubled, deeply bifid with subulate lobes: ♀ inflo-

* Hedwigia, xxvii, 289. *pl. 11. f. 9, 19–17.* 1888.

† Cf. Goebel, Organographie der Pflanzen, 286. 1898.

rescence borne on a principal branch, innovating on one side, the innovation often floriferous; bracts smaller than the leaves, plane, entire, without clear indication of lobule; bracteole usually absent;* perianth variable in shape: ♂ spike small, occupying a short lateral branch; bracts inflated, subequally bifid.

1. **Colurolejeunea tenuicornis** sp. nov.

Lejeunea calyptrifolia, var. Ångstr. Öfversigt af Kongl. Vetensk. Akad. Förhand. xxix, Häft 4, 28. 1872 (misprinted "*L. calyptrata*").

Plate LIX., figs. 17–21.

Autoicous: plants pale green, scattered or in small tufts: stems sparingly branched: leaves distant, ascending in a curved line from the axis and not at all adherent to substratum, oblong in general outline and gradually narrowed above into a long, hollow slender horn, about half the length of the entire leaf and finely denticulate at the apex (with two or three teeth), free portion of lobe orbicular from a broad base, truncate, entire; lobule tubular, the free margin strongly involute; sac inflated in lower part, then narrowing into horn; leaf-cells thin-walled, papillose in narrowing portion of sac: underleaves distant, bifid to near the base with slender subulate divisions and obtuse sinus, entire: ♀ inflorescence borne on a principal branch, innovating on one side; bracts oblong or obovate, rounded or obliquely truncate at the apex, entire; bracteole apparently wanting; perianth oblong or obovate from a narrow base, truncate at the apex and with a very short beak, terete below, five-keeled in upper part, the keels running out into long, horizontally spreading horns, denticulate at the end: ♂ spike small, occupying a short branch; bracts in two or three pairs; antheridia two in each axil.

Stem 0.08^{mm} in diameter, leaf 1.6 x 0.25^{mm}, underleaf 0.15 x 0.15^{mm}, cells at free margin of lobe 20μ in diameter, on surface of sac 23 x 17μ, bracts 0.4 x 0.1^{mm} perianth 0.6 x 0.2^{mm}.

On leaves of a fern. Oahu: Nuuanu (Cooke); also collected by Andersson.

The rare European *C. calyptrifolia* (Hook.) Schiffn., as represented in the Kew Herbarium, is very close to this curious Hawaiian plant but differs in the much shorter horns of its leaves and perianths.

* A bracteole is described for *C. obtusa* Steph. (Hedwigia, xxx, 208. *pl. 29. f. 31–34.* 1891), and for *C. Ari* Steph. (l. c. xxxv, 73. 1896).

In addition to the Lejeuneæ described and noted in this paper, the two following species, both of which are rather widely distributed in tropical America, are accredited to the Hawaiian Islands: *Prionolejeunea microdonta* (Gottsche) Steph. and *Stictolejeunea squamata* (Willd.) Schiffn. I have looked in vain for Hawaiian specimens of these plants in the herbaria at Kew and Berlin, and Herr Stephani makes no mention of such specimens in his paper on the *Lejeuneæ* in the Lindenberg Herbarium at Vienna. I have therefore omitted them, as it is probable that they were listed on incorrect determinations.

Yale University.

Explanation of Plates.

Plate XLIV.

Frullania Aongstroemii Evans.—Fig. 1. Part of stem with perianth and androecium, postical view, ×14.—Fig. 2. Part of stem, postical view, ×14.—Fig. 3. Leaf, antical view, ×14.—Figs. 4, 5. Bases of branches, postical view, ×14.—Fig. 6. Cells from middle of lobe, ×255.—Fig. 7. Innermost bracts and bracteole, ×14.—Fig. 8. Bracts and bracteole of second row, ×14.—Figs. 9, 10. Bract and bracteole of third row, ×14.—Fig. 11. Transverse section of perianth, ×14. All figures drawn from specimens collected by Mr. Cooke at Luakaha, on the island of Oahu.

Frullania Oahuensis Hampe.—Fig. 12. Part of stem with perianth, postical view, ×28.—Fig. 13. Leaf, antical view, ×28.—Fig. 14. Base of branch, postical view, ×28.—Fig. 15. Cells from middle of lobe, ×255.—Figs. 16, 17. Bracts and bracteole of innermost row, ×28.—Fig. 18. Bract and bracteole of second row, ×28.—Fig. 19. Bract and bracteole of innermost row from another involucre, ×28. All figures drawn from specimens collected by Mr. Cooke on the island of Kauai.

Plate XLV.

Frullania Sandvicensis Ångstr.—Fig. 1. Part of stem, postical view, ×14.—Fig. 2. Leaf, antical view, ×14.—Fig. 3. Base of branch, postical view, ×14.—Fig. 4. Cells from middle of lobe, ×255.—Figs. 5, 6. Bracts and bracteole of innermost row, ×14.—Fig. 7. Perianth, ×14.—Figs. 1–4 from specimens collected by Mr. Heller at Nuuanu, on the island of Oahu; Figs. 5–7 from specimens collected by Mr. Cooke on the same island.

Frullania Meyeniana Lindenb.—Fig. 8. Part of stem with perianth and androecium, postical view, ×28.—Fig. 9. Leaf, antical view, ×28.—Fig. 10. Base of branch, postical view, ×28.—Fig. 11. Cells from middle of lobe, ×255. Fig. 12. Bracts and bracteole of innermost row, ×28.—Figs. 13, 14. Bracts and bracteole of second row, ×28. All figures drawn from specimens collected by Mr. Cooke at Kilohana, on the island of Kauai.

Plate XLVI.

Frullania apiculata (R. Bl. & Nees) Dumort.—Fig. 1. Part of stem with perianth and androecium, postical view, ×20.—Fig. 2. Part of stem, antical view, ×20.—Figs. 3, 4. Bases of branches, postical view, ×20.—Figs. 5, 6. Bases of branches, antical view, ×20. Fig. 7. Cells from middle of lobe, ×360.—Figs. 8–10. Bracts and bracteole of innermost row, ×20.—Figs. 11–13. Bracts and bracteole of second row, ×20. All figures drawn from specimens collected by Mr. Cooke at Lulumahu, on the island of Oahu.

Plate XLVII.

Frullania hypoleuca Nees.—Fig. 1. Part of stem with perianth and androecia, postical view, ×14.—Fig. 2. Leaf, antical view, ×14.—Fig. 3. Base of branch, postical view, ×14.—Fig. 4. Cells from middle of lobe, ×255.—Figs. 5–6. Bracts and bracteole of innermost row, ×14.—Figs. 7–9. Bracts and bracteole of second row, ×14.—Figs. 10, 11. Bracts and bracteole of third row, ×14. All figures drawn from specimens collected by Mr. Cooke on Mt. Tantalus, on the island of Oahu.

Jubula piligera (Aust.) Evans.—Fig. 12. Part of stem with perianth and androecium, postical view, ×14.—Fig. 13. Part of stem, antical view, ×14.—Fig. 14. Base of branch, postical view, ×14.—Fig. 15. Base of same branch, antical view, ×14.—Fig. 16. Cells from middle of lobe, ×255.—Figs. 17–19. Bracts and bracteole, ×14.—Fig. 20. Underleaf next bracteole, ×14. All drawings from specimens collected by Mr. Baldwin on the island of Kauai.

Plate XLVIII.

Lophotejeunea subnuda (Mitt.) Steph.—Fig. 1. Part of stem with perianth and androecium, postical view, ×14.—Fig. 2, Part of stem, antical view, ×14.—Fig. 3. Cells from middle of lobe, ×255.—Figs. 4–6. Bracts and bracteole. All figures drawn from specimens collected by Mr. Cooke on the island of Oahu.

Platylejeunea baccifera (Tayl.) Steph.—Fig. 7. Part of stem with ♀ inflorescence, postical view, ×15.—Fig. 8. Cells from middle of lobe, ×255.—Figs. 9–11. Bracts and bracteole, ×14. All drawings from specimens collected by Menzies on the island of Hawaii.

Marchesinia Mittenii Evans.—Fig. 12. Part of stem, postical view, ×14.—Fig. 13. Cells from middle of lobe, ×255.—Fig. 14. Free margin of lobule, ×200. All figures drawn from the type-specimens.

Plate XLIX.

Thysananthus elongatus (Aust.) Evans.—Fig. 1. Part of stem with perianth, postical view, ×16.—Fig. 2. Part of sterile stem, postical view, ×16.—Fig. 3. Part of stem with perianth, postical view, ×16.—Fig. 4. Part of stem, antical view, ×16.—Fig. 5. Perianth and bracts, antical view, ×16.—Fig. 6. Cells from middle of lobe, ×290.—Figs. 7–9. Bracts and bracteole, ×16.—Figs. 10, 11. Bracts and bracteole from another involucre, ×16.—Figs. 12, 13. Transverse sections of perianths, ×32. Fig. 1 is drawn

from the type-specimen; Figs. 2 and 6–9, from specimens collected by Mr. Cooke at the foot of Konahuanui on the island of Oahu; Figs. 4, 5, 13, from specimens collected by Mr. Heller in the same locality; and Figs. 3 and 10–12, from specimens collected by Mr. Cooke at Nuuanu, also on Oahu.

Plate L.

Harpalejeunea pseudoneura Evans.—Fig. 1. Part of stem with perianth and ♀ inflorescence, postical view, ×36.—Fig. 2. Part of stem, antical view, ×36. Fig. 3. Part of stem, postical view, ×36.—Fig. 4. Cells from middle of lobe, ×325.—Fig. 5. Apex of lobe, ×260.—Fig. 6. Underleaf, ×260.—Figs. 7–9. Bracts and bracteole, ×36. Figs. 1 and 7–9 are drawn from specimens collected by Mr. Cooke on Konahuanui, and the other figures from specimens collected at Nuuanu, both stations being on the island of Oahu.

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IX.—Notes on some Type-Specimens of Myxomycetes in the New York State Museum.—By W. C. Sturgis, Ph.D.

Among the earlier students of the Myxomycetes in this country, Professor C. H. Peck of the New York State University stands pre-eminent for the number of species recorded and described. A careful examination of Professor Peck's Annual Reports from 1869 to 1893 reveals the fact that during that period no less than 107 species were recorded by him, largely from the State of New York. Of these, 33 are described as new.

Until 1875, the date of Rostafinski's Monograph, the facilities for the systematic study of the Myxomycetes were very meagre. It is not surprising, therefore, to find that much of the work done by Professor Peck, previous to that date, had to undergo considerable revision later. In his Thirty-first Report, for the year 1877, he gives a list of the species recorded by him up to that time, and the same revised in accordance with Rostafinski's Monograph. It is a notable fact that of the 77 species included in this list, 44 remain unchanged in the revision. But, in common with all American students of the Myxomycetes, Professor Peck labored under the disadvantage of having access to very few, if any, of the European type-specimens which formed the basis of Rostafinski's Monograph. His revision, therefore, was based on descriptions and figures merely, and, as was to be expected under the circumstances, did not prove to be final. As time progressed and the critical study of the group began to feel the stimulus of Rostafinski's work, further revision became necessary. Many of Professor Peck's species were either eliminated or transferred by the author himself, but a number still remained awaiting careful examination and final disposition. When Mr. Arthur Lister undertook the task of preparing a monograph of the Myxomycetes, and later when Professor Macbride did the same for the North American species, it became necessary, of course, for both authors to take cognizance of Professor Peck's species and to assign them to definite positions. This, however, was a matter of considerable difficulty. That author's original descriptions and figures, judged by modern standards, are in most cases inadequate, and, so far as I can learn, the specimens themselves were never generally distributed, indeed some of them appear now to be lost. A few were

apparently sent to Dr. Rex, or at least examined by him, but as a rule Mr. Lister was obliged to rely chiefly upon the original descriptions or upon specimens sent to him by Dr. Rex as authentic. How far Professor Macbride was enabled to examine the type-specimens I do not know, but my impression is that his knowledge of them rests upon the same basis as that of Mr. Lister. It is interesting, therefore, to note the history of these thirty-three species.

The following list includes, I believe, every species described by Professor Peck; in each case I have given the original name, the name as it appeared after revision by the author, and the final disposition of the species by Messrs. Lister and Macbride respectively.

From an examination of this list of species, it is apparent that there exists, among the authorities, a considerable difference of opinion with regard to many of them. This seems to be due in a measure to the fact that the type-specimens themselves have not been sufficiently examined. Acting upon this supposition, I requested from Professor Peck permission to examine the material in the herbarium of the New York State Museum at Albany. This was most courteously accorded me, and I desire here to express my thanks to Professor Peck for his kindness in the matter. In November, 1899, I visited Albany and examined the greater portion of the Myxomycetes in the herbarium, paying special attention to the species originally described by Professor Peck. Notes were made upon each one, indicating the habit, color, and other external features, while for the microscopic detail, mountings in glycerine were made upon glass slides and preserved for future study.

Of the 33 species originally described by Professor Peck, type-specimens of 17 were examined on the spot. Later I received, through the kindness of Professor Peck, 10 more type-specimens not before examined, making 27 in all. These species are marked with an asterisk in the list. Of the remaining 6 species, *Didymium angulatum* is not represented in the herbarium; the specimens of *Stemonitis Morgani*, *Comatricha subcæspitosa* and *Comatricha longa* are not at present accessible; *Didymium oxalinum*, though not included in the collection, has been otherwise, and doubtless correctly, referred by Professor Peck himself; *Aethalium geophilum* has been decided by Professor Peck to belong, not to the Myxomycetes but to the doubtful genus *Hyphelia*, Fr., a near relative of *Botrytis*, and is therefore not included in the list.

For the reasons above stated it has seemed to me highly advisable that the type-specimens still existing should be accurately described

Peck.	Peck.	Lister.	Macbride.
*Dictydium magnum, Pk.	Badhamia magna, Pk.	Badhamia magna. Pk.	Badhamia capsulifera (Bull.), Berk.?
*Craterium obovatum, Pk.	Craterium obovatum, Pk.	" rubiginosa, Rost.	" rubiginosa, Rost.
*Physarum albicans, Pk.	Physarum albicans, Pk.	Physarum globuliferum, Pers.	Physarum globuliferum, Pers.
*Didymium subroseum, Pk.	" " var. subroseum, Pk.	(Not mentioned.)	(Not mentioned.)
*Physarum atrorubrum, Pk.	" atrorubrum, Pk.	Physarum pulcherrimum, B. & R.	Physarum pulcherrimum, B. & R.
* " inæqualis, Pk.	" inæqualis, Pk.	" inæquale, Pk.	" lateritium (B. & R.), Rost.
* " pulcherripes, Pk.	" pulcherripes, Pk.	" pulchripes, Pk.	" rufipes (A. & S.), Morg.
* " ornatum, Pk.	" ornatum, Pk.	" viride, Pers.?	" auriscalpium, Cke.
* " luteolum, Pk.	" luteolum, Pk.	" virescens, Ditm.?	(Not mentioned.)
* " citrinellum, Pk.	" citrinellum, Pk.	Craterium citrinellum, List.	Physarum cæspitosum, Schw.
*Didymium flavidum, Pk.	" flavidum, Pk.	(Not mentioned.)	(Not mentioned.)
*Licea ochracea, Pk.	Fuligo ochracea, Pk.	Fuligo ochracea, Pk.	Fuligo muscorum, A. & S.
*Physarum mirabile, Pk.	Physarella mirabilis, Pk.	Physarella mirabilis, Pk.	Physarella oblonga (B. & C.), Morg.
*Diderma flavidum, Pk.	Physarum contextum, Pers.	(Original name not mentioned.)	(Original name not mentioned.)
* " crustaceum, Pk.	Chondrioderma crustaceum, Pk.	Chondrioderma globosum, Rost.	Diderma crustaceum, Pk.
* " farinaceum, Pk.	" spumarioides, Rost.	(Original name not mentioned.)	(Original name not mentioned.)
*Diachæa splendens, Pk.	Diachæa splendens, Pk.	Diachæa splendens, Pk.	Diachæa splendens, Pk.
* " subsessilis, Pk.	" subsessilis, Pk.	" subsessilis, Pk.	(Not mentioned.)
Didymium oxalinum, Pk.	Physarum cinereum, Batsch.	(Not mentioned.)	(Not mentioned.)
* " connatum, Pk.	" polymorphum, Mont.	{ Physarum globuliferum, Pers.? " compressum, A. & S.? }	Physarum nephroideum, Rost.
* " eximium, Pk.	Didymium eximium, Pk.	Didymium nigripes, Fr. var. eximium.	Didymium eximium, Pk.
" angulatum, Pk.	" angulatum, Pk.	" effusum, Lk.?	(Not mentioned.)
Stemonitis Morgani, Pk.	Stemonitis Morgani, Pk.	Stemonitis splendens, Rost.	Stemonitis Morgani, Pk.
* " herbatica, Pk.	" herbatica, Pk.	" herbatica, Pk.	" axifera (Bull.), Macbr.
Comatricha subcæspitosa, Pk.	Comatricha subcæspitosa, Pk.	Comatricha obtusata, Pr.	Comatricha Persoonii, Rost.
* " longa, Pk.	" longa, Pk.	" longa, Pk.	" longa, Pk.
" æqualis, Pk.	" æqualis, Pk.	" obtusata, Pr.	" æqualis, Pk.
*Physarum cæspitosum, Pk.	{ Licea cæspitosa, Pk. Perichæna cæspitosa, Pk. }	Lindbladia Tubulina, Fr.	Lindbladia effusa (Ehr.), Rost.
*Trichia reniformis, Pk.	Trichia reniformis, Pk.	Trichia contorta, Rost.	Trichia contorta, Rost.
*Perichæna flavida, Pk.	Oligonema flavida, Pk.	Oligonema nitens, Rost.	Oligonema flavidum (Pk.), Mass.
*Oligonema brevifila, Pk.	" brevifila, Pk.	" "	" brevifila, Pk.
*Arcyria macrospora. Pk.	Arcyria macrospora, Pk.	Arcyria ferruginea, Sant.?	Arcyria ferruginea, Sant.

and their relationships determined as nearly as possible. In the following notes I have endeavored to do this, paying special attention to those species regarding which there is a considerable divergence of opinion on the part of expert authorities.

Badhamia magna, Pk. (*Dictydium magnum*, Pk.), Rep. XXIV, p. 84, 1871, and Rep. XXXI, p. 57, 1878.* Sporangia spherical to obovoid, occasionally confluent, 0·8–1^{mm} in diameter; gray, iridescent and marked with white wrinkles; clustered on long, yellowish, membranous and filiform stalks 5–7^{mm} in length. Sporangium-wall hyaline, almost devoid of lime and very delicate. Columella absent. Capillitium, a loose, brittle network of delicate, branching tubes, expanded at the angles; partly filled with small, white lime-granules, and partly empty and shrunken. Spores not clustered, dark purplish-brown, 10.5–11.5μ in diameter, minutely and equally spinulose all over. (Pl. LX, figs. 1 & 2.) *Hab.* On old *Polyporus*. *Loc.* Center, N. Y. *Leg.* C. H. Peck.

The type-specimen is a very fine and abundant one, exactly resembling in outward appearance the long-stalked forms of *B. utricularis*, Berk. It differs from that species, however, in the more delicate and less calcareous capillitium and in the character of the spores, which are not even loosely clustered and are much less distinctly spinulose. Although the spores are sometimes slightly darker on one side than on the other, when highly magnified the whole surface is seen to be evenly covered with the minute spines. From *B. hyalina* it differs in the character of the stalk, the more delicate capillitium, the segregation and finer markings of the spores, and the habitat. (Cf. Pl. LX, figs. 1–7.) For the present, at least, we must consider *Badhamia magna*, Pk., as a distinct species, though allied to *B. utricularis*, Berk., a fact also noted by Peck (Rep. XXXI, p. 57). This close relationship is emphasized by the fact noted by Lister (Mon., p. 31), that sporangia of *B. utricularis* from the same plasmodium exhibit marked differences in the quantity of lime contained in the capillitium and in the degree of agglutination of the spores. The peculiar habitat of the two species is the same.

Macbride doubtfully refers Peck's species to *B. capsulifera* (Bull.), Berk. [*B. hyalina* (Pers.), Berk.], on the mistaken supposition that the spores are coherent. In his Key to the species of *Badhamia* (N. Amer. Slime-Moulds, p. 63), it falls readily under *B. utricularis*, Berk.

* Throughout this paper these references are to the Annual Reports of the State Botanist of New York, published in the reports of the New York State Museum of Natural History.

Craterium obovatum, Pk., Rep. XXVI, p. 75, 1873. This species requires but little comment. It is a perfectly typical specimen of *Badhamia rubiginosa*, Rost., and is so referred by both Lister and Macbride. The spores are of the normal type characteristic of Lister's var. *genuina*.

Physarum albicans, Pk., Rep. XXX, p. 50, Pl. II, figs. 5–8, 1877. The very scanty type-specimen shows a few scattered sporangia, globose, pure white, and borne upon delicate, white stalks charged throughout with lime. The capillitium is very delicate but persistent, retaining the form of the sporangium after the wall of the latter has disappeared; it arises from a small, hemispherical or slightly conical, white columella. The lime-knots are small, whitish and fusiform or round. The spores are bright violet-brown, almost smooth, and measure 7.5–8.4μ in diameter. (Pl. LX, fig. 9.) These are so evidently the characteristics of *Physarum globuliferum*, Pers., that there can be no hesitation in referring the specimen to that species, as is done by Lister and Macbride. The only peculiarity about the specimen is seen in the slightly swollen bases of the stalks, filled with large, globular masses of lime and refuse matter which readily separate from the enclosing wall of the stalk. (Pl. LX, fig. 8.)

Physarum albicans, *var.* subroseum, Pk. (*Didymium subroseum*, Pk.), Rep. XXVIII, p. 54, 1875; Rep. XXX, p. 50, 1877; Rep. XXXI, p. 55, 1878. A single small specimen of this form accompanies the type-specimen of *P. albicans*, Pk. Professor Peck considered it as a variety of that species on account of "the pinkish tinge of the peridium." This feature is not now apparent and the so-called variety should be merged with the species.

Physarum atrorubrum, Pk., Rep. XXXI, p. 40, 1878. The type-specimen of this most beautiful species is rather scanty, but is quite sufficient for accurate determination. Lister and Macbride agree in referring it to *P. pulcherrimum*, B. & R., and notwithstanding the meagre character of the original description of that species and the apparent absence of any specimen of it, the words "*stipite brevi purpureo; peridio globoso floccisque lilacinis*," apply so perfectly to the species described by Peck and to no other with which we are acquainted, that we can but conclude that the two species are identical. The color of Peck's type-specimen is almost exactly that of *Dictydium umbilicatum*, Schrad. The original description of the species, repeated by Macbride (N. A. Slime-Moulds, p. 49), is thoroughly adequate and covers the main features observed in the type-specimen.

Physarum inæquale, Pk., Rep. XXXI, p. 40, 1878. The difference of opinion expressed by Lister and Macbride regarding this species rests merely on a question of nomenclature. That *Physarum inæquale*, Pk., and *Didymium lateritium*, Berk. & Rav., are the same thing, there is no room for doubt, since the fact of their identity is proved by type-specimens. If one adopts the principle that a specific, sub-specific, or varietal name originally given remains unaffected by any subsequent change in the generic name of the same species, then the name *Physarum lateritium* (B. & R.), Rost., stands, and *P. inæquale*, Pk., becomes a synonym. If, on the other hand, one prefers the principle that the first authentic specific name published under the genus in which the species now stands, shall take precedence, then the name *Physarum inæquale*, Pk., must be accepted, since, although Rostafinski transferred the present species to the genus *Physarum*, he made *lateritium* a varietal, not a specific name, and the specific name *inæquale* was the first authentic one which the species received after its transfer from the genus *Didymium*.

The type-specimen is very scanty, but it shows the rather peculiar characteristics of the species; the membranous sporangium-wall with innate, pale yellow granules of lime and beset with reddish-orange masses which give it a rugose appearance; and the large, rounded lime-knots of the capillitium, yellow, with reddish-orange centres, and connected by extremely delicate threads. The reddish masses seen on the surface of the sporangia and occupying the center of the lime-knots are amorphous accretions consisting apparently of plasmodic matter. Their appearance and structure are quite different from those of the lime-granules proper. In the type-specimen the latter are always spherical, pale yellow, and exceptionally large. The peculiar structure and double coloration of the lime-knots is very apparent in the type-specimen (although here and there one is seen which does not show the red center), and in all of the specimens of this species which I have seen. The great variation in the size of the spores which led Peck to suppose that the larger ones were "an investing membrane which encloses the true spores," is evidently due to the immature condition of parts of the specimen.

Physarum pulcherripes, Pk., Rep. XXVI, p. 75, 1873. The type-specimen is an exceptionally fine one. The following description is made from a portion of the specimen sent me by Professor Peck.

Sporangia stipitate, globose, slightly umbilicate beneath, 0.4–0.5^{mm} in diameter. Wall membranous, grey, hyaline, rugose with clusters of reddish-orange lime-granules. Stalk slender, terete, sulcate, erect or curved, twice the height of the sporangium, reddish-orange, charged throughout with lime, rising from a small, concolorous hypothallus. Columella small, conical. Capillitium delicate, persistent, hyaline. Lime-knots small, triangular, rounded, or fusiform, reddish-orange. Spores pale violet-brown, 7.5–9μ in diameter, almost smooth. *Hab.* On moss, growing on decayed wood.

The distinction between this species and *P. psittacinum*, Ditm., to which it bears a certain external resemblance, is admirably pointed out by Macbride (l. c., p. 51).

A comparison between the above description and that given by Lister of *P. pulchripes*, Pk. (l. c., p. 41), makes it evident that the latter must have been made from an authentic specimen at least, and when Lister states that he has examined a type-specimen of *Didymium Ravenelii*, B. & C., and that it is identical with Peck's species, it seems impossible to follow Macbride in regarding them as distinct. If they are the same, then assuredly Macbride is mistaken in making *Physarum murinum*, List. synonymous with *Didymium Ravenelii*, B. & C., if color counts for anything. As to the proper name for Peck's species, Lister, in retaining Peck's name (with a slight change in the orthography), seems to have overlooked the fact that Albertini and Schweinitz (Consp. Fung., p. 94), described as var. *rufipes* of *Physarum aurantium*, (Bull.) Pers., a form, the description of which might possibly apply to the species under consideration. The description, however, though long, is not sufficiently exact in detail to enable us to determine what species the authors had under consideration. They suggest that it may be worthy of specific rank and Fries accords it this position under the name *Diderma rufipes*, Fr. (Syst. Myc. III, p. 101). All we can say is that these authors described a form very similar to *Physarum aurantium* (Bull.) Pers. (*Tilmadoche mutabilis*, Rost.), but differing in the color of the stalk, which is described as "*ex aurantio rufi.*" Upon this basis Macbride rehabilitates the variety, accords it specific rank, and gives *Physarum pulchripes*, Pk., as a synonym. A safer course, and one less liable to lead to confusion, seems to be that adopted by Lister, by which the name *P. pulchripes* is retained as representing a distinct species concerning which there can be no doubt. It would, however, seem permissible, and possibly desirable, to retain the specific name *Ravenelii*, as being both the original name applied to the species

and also the first which it received after its transfer to the genus *Physarum*, and to call the species *Physarum Ravenelii* (B. & C.), Mass. This name is free from ambiguity, transgresses no accepted rule of nomenclature, and is based upon the identity of type-specimens.

Physarum ornatum, Pk., Rep. XXXI, p. 40, 1878. Of the type-specimen of this species only the scantiest vestiges remain. They consist of two or three sporangia in so immature a condition that they show no characters of diagnostic value, and a number of short, robust stalks, very dark brown in color and containing no lime. It is impossible even to guess what species they represent. The poorly-developed remains of the capillitium do not appear to be that of *Physarum auriscalpium*, Cke., to which Macbride refers the species, and its general robust habit is unlike that of *Physarum viride*, Pers., to which it is doubtfully referred by Lister. The original description quoted by Lister (Mon. p. 63) throws little light on the question. The species should be discarded.

Physarum luteolum, Pk., Rep. XXX, p. 50, Pl. II., figs. 15–18, 1877. The same general remarks apply to this species as to *P. ornatum*. The type-specimen was originally scanty and the leaf of *Cornus Canadensis* upon which the sporangia were borne was evidently dried by pressure, to the damage of the specimen. The persistent bases of the sporangia alone remain, together with bits of the capillitium here and there and a few spores. The sporangia were small (though apparently larger than those of *Physarum virescens*, Ditm.), gregarious but not clustered, and pale yellow in color. The remnants of the capillitium are very delicate, with lime-knots of medium size, angular or rounded, and whitish or pale yellow in color. The spores are pale violet-brown, very minutely spinulose, and measure 8.2–10.5μ in diameter. Neither Peck's description nor his figures are of much assistance in determining the species. In habit, color and general appearance the specimen resembled *Physarum virescens*, Ditm., var. *nitens*, List., but the lime-knots are paler in color and smaller and less branching than in that form, and the spores are decidedly larger. It is useless under the circumstances to attempt to locate the species, and therefore, in my opinion, the name should be discarded.

Physarum citrinellum, Pk., Rep. XXXI, pp. 55 & 57, 1878. This specimen is interesting as being the type of a species widely distributed by Rex, although with no statement on the part of the latter to the effect that he had even compared his specimens with the type. Lister received it from Rex and based upon that specimen his

description of *Craterium citrinellum*, List. It was distributed by Rex in Ellis & Everhart's N. Amer. Fungi, No. 2490. Macbride (l. c., p. 38) says, "Under the last name (*P. citrinellum*, Pk.) the species has been generally recognized in the United States and distributed." It is satisfactory, then, to note that the specimens so distributed are identical with Peck's type, with the unimportant exceptions that in the latter the lime-knots of the capillitium are rather smaller and the spores are smaller and decidedly less distinctly spinulose than is the case in the specimens distributed by Rex. In the type the spores measure 9.4–11.2μ as compared with 11.5–12μ in the case of the Ellis and Everhart specimens.

Peck originally called his specimen *Diderma citrinum*, Fr., a species referred by Rostafinski to *Physarum Schumacheri*, Spr. (*P. citrinum*, Schum.). When Rostafinski's Monograph appeared Peck changed the name of his specimen to *Physarum citrinellum*, Pk., and published a brief but sufficiently accurate description of it. (Rep. N. Y. St. Mus., xxxi, p. 57.) The species is certainly very closely related to at least one other. In 1818 Fries described his *Physarum flavum*. This was the same thing (*teste* Rostafinski, Mon., p. 100) as a specimen which Fries had sent to Kunze during the previous year under the name *Physarum citrinella*, Fr. This earlier name Fries disregarded in later publications, and the final form in which he left it was *Craterium flavum*, Fr. Rostafinski adopted the earlier generic name, with the remark that "the transfer of this *Physarum* to the genus *Craterium*, as Fries did later, rests on no sufficient grounds." Now the description of *Physarum flavum*, Fr., distinctly recalls Peck's species. Lister's comment on the former is: "This description applies to *Craterium citrinellum*, List.", and R. E. Fries, in his latest work on the Swedish Myxomycetes,* commenting on *P. flavum*, Fr., recognizes its close relationship to *C. citrinellum*, List., though, not having seen a specimen of the latter, he is naturally unwilling to unite the two and therefore retains the Friesian name. Personally, I have little doubt that the two forms are one and the same species, but, in default of comparative material, Peck's name must be retained for the American form. Whether we should call it a *Physarum* or should refer it to the genus *Craterium* because of the cartilaginous character of the base of the sporangium wall, is a comparatively unimportant matter of opinion.

More important is Macbride's reference of the species to *Physarum cæspitosum*, Schw. The original description of that species is brief,

* Öfersigt af Kongl. Vetenskaps-Akad. Förhandl., 1899, No. 3, p. 224.

it is accompanied by no figures, and, so far as I know, there is no authentic specimen in existence. Under these circumstances certainty is out of the question, and it seems to me unwise in principle to supersede a generally recognized name of many years' standing and referring to a well-known form, by a name to which no certainty can be attached. The original description of the shape, the habit, and the color of the capillitium of *P. cæspitosum*, Schw., seems, as noted by Lister, to apply quite as well to *P. virescens*, Ditm., as to *P. citrinellum*, Pk., if not better.

Physarum flavidum, Pk. (*Didymium flavidum*, Pk.), Rep. XXVIII, p. 54, 1875, and Rep. XXXI, p. 55, 1878. The type-specimen of this species is unfortunately immature, nevertheless the following characters can be determined from it.

Sporangia scattered, dull yellow, subglobose, sessile or shortly stipitate, 0.5–0.6^{mm} in diameter, seated upon or rising from a thin, membranous hypothallus. Stalk, when present, robust, membranous, brownish-yellow. Wall double; the outer, pale yellowish-grey, membranous above and beset with scattered aggregations of yellow lime-granules, thicker and persistent below; the inner, very delicate and colorless, widely separated from the outer wall. Capillitium composed of delicate, colorless threads with rounded lime-knots of medium size of a white or pale straw color. Spores pale violet, (black in the mass), minutely spinulose, variable in size, but averaging 9.7–11.2μ in diameter.

The almost sessile character of the sporangia, the wide space separating the inner from the outer wall, the fact that the spores form a shrunken, indurated mass, the pale color of the spores when separated, and their variable size, are all indications of immaturity. Fortunately, however, there is little choice in deciding where the species properly belongs. It is evidently an immature specimen of *Physarum citrinellum*, Pk. (*Craterium citrinellum*, List.)

Fuligo ochracea, Pk. (*Licea ochracea*, Pk.), Rep. XXVIII, p. 55, 1875, and Rep. XXXI, p. 56, 1878. The type specimen of this species is fairly abundant and in good condition. Lister's description (l. c., p. 67) fits the specimen so exactly that it is unnecessary to attempt to add to it. Macbride makes Peck's name a synonym of *Fuligo muscorum*, A. & S., a name apparently overlooked by Lister. The description and figures given of their species by Albertini and Schweinitz (Consp. Fung., p. 86, Tab. VII, fig. 1) are exceptionally good and, as stated by Macbride, they seem referable to *F. ochracea*, Pk. On the other hand, in the absence of the type-specimen, we

cannot be certain of that fact. Albertini and Schweinitz failed to realize the extreme variability of *F. septica*, Gmel., and their diagnoses of species rest largely on external characters. They were necessarily ignorant of those characters, such as the size of the spores, which serve to distinguish Peck's species from others of the genus. A degree of certainty attaches to our knowledge of *F. ochracea*, Pk., which cannot possibly attach to *F. muscorum*, A. & S., so that, although there is a strong probability that the two names refer to the same species, it does not seem wise to retain a name based on mere probability.

Physarella mirabilis, Pk. (*Physarum mirabile*, Pk.), Rep. XXXIII, p. 22, 1880. Bull. Torr. Bot. Cl., IX, p. 61, 1882. The type-specimen of this species requires no comment. It agrees perfectly with the published descriptions and so peculiar a species could hardly be confused with anything else. Whether we choose to call it *Physarella oblonga*, (B. & C.) Morg., or *Physarella mirabilis*, Pk., will depend upon which of the two general principles of nomenclature we follow.

Diderma flavidum, Pk., Rep. XXVIII, p. 54, 1875, and Rep. XXXI, p. 55, 1878. Professor Peck has very properly referred this species to *Physarum contextum*, Pers. I mention it here under the original name merely because neither Lister nor Macbride refers to that name as a synonym of *P. contextum*, Pers. The specimen requires but little comment. I have compared it with an authentic specimen received from Mr. Lister and the two are essentially identical. The sporangia of Peck's specimen are smaller and of a more greenish-yellow color than in the Lister specimen, and the spores are somewhat larger. Some of the sporangia in Peck's specimen, especially the elongated forms, show a false columella in the shape of a dense, flattened aggregation of lime-knots occupying the median line of the sporangium but entirely free from the base. It may be noted that in both specimens the lime-knots of the capillitium are white only by reflected light; by transmitted light they are of various shades of yellow.

Chondrioderma crustaceum, Pk. (*Diderma crustaceum*, Pk.), Rep. XXVI, p. 74, 1873, Rep. XXXI, p. 56, 1878. This is an interesting species on account of the confusion which exists regarding it. Lister places it under *C. globosum*, Rost., on account of the smooth outer wall, the strongly developed hypothallus, and the dark purplish-brown, spinulose spores, measuring 10–14μ in diameter. Macbride, however, describes the spores of *C. globosum*, Rost., as measuring

only 8μ in diameter, and gives this character and the less crowded habit as his reason for retaining *C. crustaceum*, Pk. as a species distinct from *C. globosum*, Rost. It will be seen, therefore, that the confusion has arisen from a misconception, not of Peck's species, but of Rostafinski's. That author gives 8.3μ as the size of the spores of *C. globosum*, and if that be correct, then it is certainly difficult to regard *C. crustaceum*, Pk. as the same species. But in the Appendix to his Monograph, Rostafinski describes a species, *C. affine*, Rost., with spores 10.8–14μ in diameter. This species is certainly very closely related to *C. globosum*, and Lister (Mon., p. 78), as the result of his examination of the type-specimens of both, states that they are identical, and, moreover, that the spores of *C. globosum* actually measure 11–13μ in diameter.

Turning now to Peck's type of *C. crustaceum*, it may be described as follows: Sporangia white, smooth, 0.5–0.7 mm in diameter, globose or obovate, angled by mutual pressure, densely crowded upon a strongly developed, white, calcareous, almost spongy hypothallus. Wall double, the outer composed of spherical lime-granules, brittle, widely separated from the membranous, gray, iridescent inner wall. Columella small but prominent, subglobose or clavate, white. Capillitium abundant, a network of pale violet, branching and anastomosing threads with occasional fusiform expansions filled with lime-granules. Spores dark purplish-brown, densely spinulose, 11.2–14.2μ in diameter. (Pl. LX, figs. 10 & 11.) That this description applies to *Chondrioderma globosum*, Rost., as understood by Lister, there can be no possible doubt. Moreover, Peck's specimen is absolutely identical with an authentic specimen of that species, collected by Mr. A. P. Morgan and sent to me by Mr. Lister.

It may not be out of place to discuss in this connection a peculiar *Chondrioderma* which was sent to me recently by Professor Peck. It forms, on dead fern-stalks, an effused crust consisting of a thin, whitish, wrinkled hypothallus, bearing closely aggregated subglobose or flattened sporangia of a whitish color with a faint pinkish tinge. The outer wall is rugose, almost farinaceous, wrinkled, very fragile, never widely separated from the membranous inner wall, and sometimes inseparable from it. The columella is pulvinate and the capillitium scanty. Judged by external characters, the specimen might well pass for *C. spumarioides*, Rost. But the spores, instead of being of the pale color and small size characteristic of that species, are dark violet-brown, spinulose, darker and more distinctly spinulose on one side, and measure 11.2–15μ in diameter. These spores are iden-

tical with those of *C. globosum*, Rost., according to Lister's measurements; moreover, the capillitium-threads in this specimen show here and there fusiform expansions filled with lime-granules, a character also seen in the capillitium of *C. globosum*. The specimen is unquestionably an immature example of that species. A specimen of *C. spumarioides*, Rost., collected by myself and authenticated by Mr. Lister, shows the pinkish tinge seen in the specimen of *C. globosum* received from Professor Peck, and has a dark capillitium, and fairly dark spores measuring 9.3–11.2 μ. Still another has the pale capillitium and spores of typical specimens, but the spores measure 8.2–11.2μ in diameter. This is not the place to discuss these specimens in detail. I mention them merely to emphasize the fact that there can be no sharp line drawn between *C. globosum*, Rost. and *C. spumarioides*, Rost. As a rule, however, specimens showing, when mature, a smooth outer wall, strongly developed hypothallus, capillitium with occasional expansions containing lime, and dark, coarsely spinulose spores measuring 10–14μ in diameter, may be placed under *C. globosum*, Rost.; the name *C. spumarioides*, Rost. may be applied to specimens showing, even when mature, a rugose, fragile outer wall, thin and crust-like hypothallus, pale capillitium, and pale, minutely spinulose spores measuring 8–10μ (Cf. Pl. LX, figs. 12–13 & 14–15).

To the former species *C. crustaceum*, Pk. unquestionably belongs, if we accept Lister's conception of that species. I have given above my reasons for so doing.

Diderma farinaceum, Pk., Rep. XXVI, p. 74, 1873, and Rep. XXXI, p. 56, 1878. This is a perfectly normal specimen of *Chondrioderma spumarioides*, Rost., and was so referred by Peck in the second publication noted above.

Diachæa splendens, Pk., Rep. XXX, p. 50, Pl. II, figs. 1–4, 1877. This species has rightly been retained by both Lister and Macbride and the descriptions given by both authors are so admirable that it is unnecessary to add anything here. The type agrees perfectly with the published descriptions and figures. The spore-surface, beset with large, scattered, truncate tubercles which are occasionally confluent in short bands, is sufficient to distinguish this species from the globose form of *Diachæa elegans*, Fr. (Cf. Pl. LXI, figs. 21 & 22.) These tubercles, when examined with a $\frac{1}{12}$ Homog. Im. lens, are seen to be, not solid tubercles, but clusters of blunt, spinous processes, the variability in the size of the seeming tubercles being due to the greater or smaller number of spines composing the clusters. Occasionally the spines occur singly, interspersed among the tubercles.

(Pl. LXI, fig. 21*a*.) A somewhat similar instance of compound papillæ was noted by Rex in the case of *Diachæa Thomasii*, Rex. (Proc. Acad. Nat. Sc. Phil., 1893, p. 368.)

Diachæa subsesselis, Pk., Rep. XXXI, p. 41, 1878. Peculiar interest attaches to the type-specimen of this species since no accurate description of it has ever been published. Fortunately it is so well-marked a species that the original brief description has proved sufficient to enable later investigators to identify it with a fair degree of certainty. That Rex had seen the type, seems evident from the accuracy with which he described the episporic markings characteristic of the species (l. c., p. 368. Cf. Lister, Mon. p. 92). Lister has described it at some length on the basis of a specimen collected by him in September, 1896, in Bedfordshire, England, which agreed with the original description and possessed spores marked as described by Rex. A portion of this specimen was sent to me by Mr. Lister. In January, 1899, I collected it at Bonchurch, Isle of Wight, and in the following August I made a small gathering of it at Poquonock, Conn. All of these specimens are identical with one another and with the type. Inasmuch as Lister's description of the species may not be accessible to most American students, it may be well to describe briefly the salient features of the type-specimen. They are as follows: Sporangia subglobose, 0.5–0.6^{mm} in diameter, sessile or stipitate. Stalk, when present, very short, robust, tapering, filled with white lime or dark with included refuse matter. Wall membranous, hyaline, slightly iridescent, splitting irregularly from above. Columella pulvinate, short-conical, or sometimes almost obsolete. Capillitium dark violet-brown, paler below. Spores violet-brown, 9.3–11.2μ in diameter, marked with an irregular, broken network, composed of minute warts and covering the greater part of the surface. (Pl. LXI, fig. 20.) *Hab.* on dead leaves.

The sessile or short-stalked habit of this species, and the peculiar episporic markings, are quite sufficient to distinguish it from any other *Diachæa*. It is apparently rare in this country, as Macbride makes no mention of it. I am unable to detect the greenish tint said, by Lister, to be characteristic of the spores of this species. (Journ. of Bot., Vol. XXXV, p. 213, 1897.)

Didymium oxalinum, Pk., Rep. XXVIII, p. 54, 1875, and Rep. XXXI, p. 57, 1878. No specimen bearing this name is now to be found in the collection. In his Thirty-first Report, p. 57, Peck remarks "*Didymium oxalinum*, Pk., is probably only a form of *Physarum cinereum*, and is therefore omitted." The original descrip-

tion contains nothing which militates against this statement and the latter may be accepted as correct.

Didymium connatum, Pk., Rep. XXVI, p. 74, 1873, and Rep. XXXI, p. 55, 1878. This species is represented in the N. Y. St. Mus. Herb. by two specimens. One is marked, "*Physarum polymorphum*, Mont. (*Didymium polycephalum*, Rav., *Didymium connatum*, Pk.), Catskill Mts., *leg.* C. H. Peck." The label upon the other reads "*Didymium connatum*, Pk., Portville, *leg.* C. H. Peck." Both of these specimens belong to the same species, the only difference between them being that in the first the sporangia are separate and in the second they are connate in clusters of two to five. Peck's reference of them to *Physarum polymorphum*, Mont., is evidently an error since the sporangia do not exhibit the compressed or convolute form characteristic of that species. The connate form is immature, but both specimens are distinctly referable to *Physarum nephroideum*, Rost. (*P. compressum*, A. & S. var. δ, List.), one of the commonest species in northern New England. The robust habit; the absence of lime in the stalk except as an external crust; the large, rounded, white lime knots of the capillitium; the absence of a columella; the large, dark, violet-brown, minutely spinulose spores, are all features which distinguish this species from such related forms as *P. globuliferum*, Pers., *P. leucophæum*, Rost., and *P. leucopus*, Lk. Neither specimen shows the "ovoid or reniform, laterally compressed" sporangia characteristic of typical *P. nephroideum*, Rost. (Cf. Lister, Mon. p. 54), so that whether we call them a globose form of that species or refer them to Lister's globose variety of *P. compressum*, A. & S., is a matter of little importance. Macbride discards the latter name on the ground that no degree of certainty can be derived from the original description. I am inclined to share this opinion and to accept Rostafinski's name for the species under consideration. This globose form, so typically American and so constant in shape, is possibly deserving of something more than varietal rank, but inasmuch as other writers, more competent than I to judge, have not seen fit to establish it as a separate species, it seems inadvisable for me to attempt it.

Mr. Morgan has described it in his "Myxomycetes of the Miami Valley" and considers it a distinct species (Journ. Cinn. Soc. Nat. Hist., August, 1896, p. 92), but unfortunately he has referred it to *Physarum connexum*, Lk., a species suppressed by Rostafinski as being merely a clustered form of *P. leucophæum*, Fr. (Rost. Mon., pp. 113 & 114.) In the absence of the original type and of any

authentic specimen of Link's species, the acceptance, as final, of Rostafinski's judgment concerning it, seems unavoidable.

Didymium eximium, Pk., Rep. XXXI, p. 41, 1878. A small bit of the type of this species, consisting of a portion of a leaf bearing three sporangia, was sent me by Professor Peck. It presents the following characters.

Sporangia globose, slightly umbilicate beneath, 0.4–0.6^{mm} in diameter, white, stipitate. Stalk slender, 1^{mm} long, golden-brown, longitudinally wrinkled, expanded below and almost black from included refuse matter, rising from a small hypothallus. Sporangium-wall hyaline, colorless, beset with stellate crystals. Columella irregularly subglobose, golden-brown. Capillitium scanty, consisting of delicate, colorless threads expanded at their point of origin from the columella. Spores rather dark, violet-brown, minutely spinulose, 7.5–9μ in diameter.

I have compared this specimen most carefully with a large number of authentic specimens of *Didymium nigripes* (Lk.) Fr. and *D. xanthopus* (Ditm.) Fr. in my collection, and with specimens distributed in Ellis & Everhart's N. A. Fungi, including two named by Rex. *D. eximium*, Pk. No. 412, in that collection, is the typical *D. microcarpon* of Fries and Rostafinski, common everywhere, and usually occurring on *Sphagnum*. No. 2089 is the same, differing only in its habit (a dead herbaceous stem) and its slightly larger, darker, and more distinctly spinulose spores.* Both show the white sporangia, pale yellowish subglobose columellas and slender brownish-orange stalks characteristic of *Didymium xanthopus*, Fr. No. 1393, according to Macbride (l. c., p. 91), represents Rex's conception of *Didymium nigripes* (Lk.) Fr. The former notes the small size of the sporangia, "about 4^{mm}," and the correspondingly small spores "6–8μ." "Otherwise," he writes, "the species is hardly more than a variety of the next" (*D. xanthopus*, Fr.). In this I can fully agree with Professor Macbride. But Rex's specimen is hardly typical of *D. nigripes*. An authentic specimen of the latter, furnished me by Mr. Lister, has pure white sporangia measuring 0.5^{mm} in diameter

* It should be noticed that this specimen was distributed by Dr. Rex under the name *D. eximium*, Pk., that he recognized important differences between it and the specimen later distributed under the same name (No. 2493), and that his conclusion regarding these two specimens was expressed in the following words: "They apparently form the extreme limits of what must be considered an extremely variable species, the intermediate and connecting links of which exist." (Proc. Acad. Nat. Sci., Phil., 1890, p. 195.)

and the spores measure 7.8–9.3μ. On this basis there is not even a varietal difference between *D. nigripes* and *D. xanthopus*. The difference expressed by the two specific names is merely one of degree. The color of the stalk is essentially the same in both, though it has a much darker tone in the former than in the latter.

I have dwelt at length upon these two species in order to call attention to the resemblance existing between them and the type of *Didymium eximium*, Pk., described above. I cannot but conclude that all three represent one and the same species, and that Peck's species, from the standpoint of color, occupies an intermediate position between the other two.

On referring to the second specimen distributed by Rex as *D. eximium*, Pk. (N. A. F., No. 2493), we find a most interesting form, apparently the one upon which Macbride and Morgan based their descriptions of that species. In many respects, such as the habit, the size, and the character of the spores, it agrees fairly well with Peck's type; in others, this is not true. The sporangia have a decidedly yellowish tinge, which, on closer examination, is seen to be due to aggregations of small, spherical, bright yellow granules imbedded in the hyaline wall. The columella is irregularly subspherical or flattened and of an orange-yellow color. The capillitium consists of delicate, hyaline threads, expanded at the base and often for a considerable distance upwards; similar expansions, of a more or less fusiform or elongated shape, are of frequent occurrence in the continuity of the threads. (Pl. LX, figs. 16 & 17.) These expansions are filled with spherical, yellow granules similar to those imbedded in the sporangium-wall. The capillitium thus presents somewhat the appearance of a *Physarum*-capillitium. That the granules are not composed of lime, however, is seen from the fact that upon treatment with dilute potassium hydrate they dissolve at once and completely, leaving the expanded portions of the thread empty and hyaline. They are evidently organic bodies. The expanded portions in connection with the surface of the columella are conical or tapering and persistent, so that upon dissecting away the looser part of the capillitium the columella appears beset with the long, somewhat spine-like bases of the capillitium threads. (Pl. LX, fig. 16. Cf. Macbride, l. c., p. 92.) The spores are rather dark, violet-brown, distinctly spinulose, and measure 9.3–11.2μ in diameter. This specimen certainly exhibits a marked variation from normal forms of either *Didymium nigripes*, Fr., or *D. xanthopus*, Fr., in the presence of the peculiar granules of organic

matter above mentioned. It is equally, and for the same reason, distinct from the type-specimen of *D. eximium*, Pk. The question then arises whether this feature is of sufficient importance to warrant the erection of a new species. I should be inclined to answer affirmatively, were it not for one fact. The specimen of *D. nigripes*, Fr., distributed as No. 1393 in Ellis & Everhart's N. A. Fungi, though scanty and partially immature, presents very similar features in its capillitium. The bases of the threads are expanded in the same manner and the threads themselves show similar fusiform expansions in abundance. The contents of these expansions are of a violet-brown color and are more homogeneous and less soluble in alkaline solutions than in the case of the specimen distributed as *D. eximium*, Pk., but there can be no doubt that both are analogous structures. No other specimen of *D. nigripes* which I have examined shows them, and I can but conclude that, in this case at least, they are abnormal structures of no taxonomic value.

We have seen that Rex regarded Nos. 2089 and 2493 of the N. A. Fungi as the extreme limits of a single, variable species. We have further seen that Macbride is correct in referring No. 2089 to *D. xanthopus*, Fr. The type-specimen of *D. eximium*, Pk., is almost identical with No. 2089 ; it certainly is in the direct series of which Nos. 2089 and 2493 are the "extreme limits." But in my opinion, as above expressed, there is no essential difference between *D. xanthopus*, Fr. and *D. nigripes*, Fr., hence I must conclude that Lister is correct in regarding *D. eximium*, Pk., as a mere variety of *D. nigripes*, Fr. If Rex was correct in referring the very peculiar form distributed by Ellis & Everhart as No. 2493 to *D. eximium*, Pk., it is certainly a very well marked variety and may yet prove to be deserving of specific rank. The type of that species, however, is not distinguishable from *D. nigripes*, Fr. (*D. xanthopus*, Fr.).

Didymium angulatum, Pk., Rep. XXXI, p. 41, 1878. No type-specimen of this species exists and the original description is not sufficient to enable us to locate the species with any degree of certainty. Lister refers it tentatively to *Didymium effusum*, Lk., and Macbride makes no mention of it. Under these circumstances the species should be excluded.

Stemonitis Morgani, Pk., Bot. Gaz., V. p. 33, 1880. The type-specimen of this species has been unfortunately stored away where it is not at present accessible ; nothing definite, therefore, can be said regarding it. Lister, on the basis of presumably authentic specimens collected by Wingate and distributed in Ellis & Ever-

hart's N. A. Fungi, No. 2088, identifies it with Rostafinski's type of *S. splendens* from Cuba. Under that species he also places *S. Bauerlinii*, Mass. and its var. *fenestrata*, Rex; *S. Webberi*, Rex; and *S. confluens*, Cke. & Ell. Macbride disregards, as species, *S. splendens*, Rost. and *S. Bauerlinii*, Mass., but gives specific rank to Rex's variety of the latter, and restores *S. Morgani*, Pk., *S. Webberi*, Rex and *S. confluens*, C. & E., as autonomous species. He thus deprives *S. splendens*, Rost. of all its varieties, but fails to indicate what disposition we are to make of that species itself. In view of this extreme divergence of opinion on the part of two authors, it is interesting to note the view of this matter entertained by a third authority.

In December, 1892, I received from Dr. Rex a series of six specimens representing various intergrading forms of essentially one type, and all referred to *S. splendens*, Rost. They include the following names: *S. Bauerlinii*, Mass. ("according to the type sent by Massee"); *S. Bauerlinii*, Mass., var. *fenestrata*, Rex; *S. Morgani*, Pk.; and *S. Morgani*, Pk., var. *fenestrata*, Rex. In the letter referring to these specimens, Dr. Rex says: "They illustrate a series which must, I believe, *all* be taken into *Stemonitis splendens*, Rost. They represent a series (I have still other links) which include, I think, *S. Bauerlinii*, Mass. and *S. Morgani*, Pk. I shall also have to include my own species *S. Webberi*." This is precisely the position taken by Lister, and taking it for granted that the distributed specimens of *S. Morgani*, Pk., are actually that species, Lister's opinion seems to me to be in accordance with the facts.

Stemonitis herbatica, Pk., Rep. XXVI, p. 75, 1873, and Rep. XXXI, p. 58, 1878. Like *S. Morgani*, Pk., this species is an illustration of the extreme difficulties attending the effort to draw sharp lines of distinction between the so-called species of this perplexing genus. We may, with almost equal propriety, select certain "centres" and group around them extensive series of intergrading forms, or select the terminal extremes of such series and regard them as more or less fixed species. The difficulty of adopting either method exclusively lies in the fact that two observers examining the same specimen may yet disagree as to its apparently essential features. Thus, in the case before us, both Mr. Lister and Professor Macbride have examined the type of *S. herbatica*, Pk., yet the former describes the spores as "purplish" (not ferruginous), as in *S. splendens*, Rost., while the latter describes the spore-mass as "ferruginous," as in *S. ferruginea*,

Ehr. The reason for so fundamental a difference of opinion is seen when we examine the actual specimens. I have before me an authentic specimen of *S. ferruginea*, Ehr., received from Mr. Lister; the type-specimen of *S. herbatica*, Pk.; and a large number of specimens of the latter, most of them collected in this country and examined by Mr. Lister, one of them collected in England by Mr. Lister himself. The type-specimen of *S. herbatica*, Pk. has the sporangia densely aggregated, forming a tuft on grass; they measure 6–7^{mm} in height. I can distinguish no difference, in the color of the spore-mass or of the individual spores, between this and the specimen of *S. ferruginea*, Ehr. The habit of the two is also identical. The English gathering of *S. herbatica*, Pk., has distinctly darker spores of a purplish tinge, whether examined in the mass or shed upon white paper. All of the other specimens are in the form of loose tufts, 10^{mm} high, growing on dead wood. The spores in the mass have the light greyish-violet color of the type, neither as purplish as those of *S. splendens*, Rost., nor as ferruginous as those of *S. Smithii*, Macbr. For my own part, and judging merely by the specimens in my possession, I cannot with any certainty distinguish between *S. herbatica*, Pk., and *S. ferruginea*, Ehr.

The same conclusion is reached by Macbride, who, however, unites both species under the name *Stemonitis axifera*, (Bull) Macbr. Expediency and established usage would alike seem to render inadvisable the adoption of Bulliard's name, even if his description and figures referred with certainty to the species under consideration. They apply quite as well, if not better, to the form now known as *S. Smithii*, Macbr.

COMATRICHA SUBCÆSPITOSA, Pk., Rep. XLIII, p. 71, Pl. III, figs. 6–9, 1890.

COMATRICHA LONGA, Pk., Rep. XLIII, p. 70, Pl. III, figs. 1–5, 1890.

The type-specimen of neither of these species is at present accessible. *Comatricha subcæspitosa*, Pk. is placed by Lister under *C. obtusata*, Pr., on the basis of a slide-mounting of the type, furnished by Rex. (Lister, Mon. p. 118.) Macbride rejects the name *C. obtusata*, Pr., on the ground that the figure of that species given in Sturm's Deutsch. Fl., Pl. LXX, is rather that of *Enerthenema*, and substitutes the name *C. nigra*, (Pers.) Schrt. I am inclined to agree with Professor Macbride in regarding both the description and the figures of Preuss' species as referable to *Enerthenema*. If this be correct, and if we proceed on the principle of the

inherent vitality of specific names, then we must accept the name given by Persoon, notwithstanding the fact that later he himself reduced it to varietal rank under his species *Stemonitis ovata*. (Syn. Meth. Fung., p. 189.) If, however, we decide to adopt the first specific name given under the genus to which the species is now referred, then *C. alta*, Pr. (according to the synonymy given by Lister), would seem to be the proper name of this species. This question will be more fully discussed later, with reference to *Comatricha æqualis*, Pk.

Under the name *Comatricha nigra*, (Pers.) Schrt., Macbride includes only the long-stalked form with subglobose sporangia. *C. subcæspitosa*, Pk. does not answer to this description, and Macbride therefore refers it to *C. Persooni*, Rost.

Comatricha longa, Pk. is regarded as a good species by both Lister and Macbride.

Comatricha æqualis, Pk., Rep. XXXI, p. 42, 1878, and Rep. XLVI, p. 57, 1893. The type-specimen of this species is in good condition and exhibits the following characters.

Sporangia gregarious or loosely clustered, total height 3.6–6.3^{mm}, cylindrical, obtuse, greyish-violet, stipitate. Wall evanescent. Stalk 2.2–2.8^{mm} long (about equalling the sporangium in length, hence the specific name), black, slender, subulate, expanded at the base, rising from a thin, brown hypothallus. Columella gradually merging, toward the apex of the sporangium, into the capillitium. Capillitium a dense network of violet-brown threads, its ultimate branches paler and anastomosing, but showing many free colorless tips. Spores rather dark, violet-brown, almost or quite smooth, 7–7.5μ in diameter.

I do not find this species so easy to dispose of as does Professor Macbride. He regards it as a distinct and easily recognizable one. This depends, however, upon the conception which one has formed of its near ally *C. nigra*, (Pers.) Schrt. If we limit that species to purplish-brown forms with small, more or less globose sporangia, as Macbride does, then his conclusion regarding such elongated forms as *C. æqualis*, Pk., and *C. Suksdorfii*, Ell. & Ev., is logical and unavoidable; they must be regarded as distinct species. Such, however, was not Rostafinski's conception, as is evident from his figures of *C. Friesiana* (Mon. Tab. IV, fig. 51), as well as from the specimens (Rab. Fung. Eur., No. 568) to which he refers (l. c., p. 200), as illustrative of vars. *oblonga* and *obtusata* of that species. Lister's conception of *C. Friesiana*, (*C. obtu-*

sata, Pr.), agrees with Rostafinski's, and he includes under it the elongated forms mentioned above. Specimens in my own collection show, in the same group, small, almost globose sporangia and others which are cylindrical and 2–3^{mm} long. When these, and others even more elongated, exhibit the same color (which, in the case of *C. æqualis*, Peck describes as "almost exactly like *Stemonitis fusca*"), the same type of capillitium and the same almost smooth spores,* and when these characters run, without essential variation, through a large series of forms exhibiting sporangia of very varied degrees of height, it would seem but natural to regard the constant characters as diagnostic and to attach to the one character which varies, merely a varietal significance. On this basis *Comatricha æqualis*, Pk. can only be regarded as a variety of *C. nigra*, (Pers.) Schrt. [*C. Friesiana*, (D By.) Rost.]†

Perichlæna cæspitosa, Pk. (*Physarum cæspitosum*, Pk. *Licea cæspitosa*, Pk.), Rep. XXVI, p. 75, 1878; Rep. XXVIII, p. 85, 1875; and Rep. XXXI, p. 57, 1878. As noted many years ago by Rex (Bot. Gaz., vol. xvii., p. 202, 1892), this is a fine specimen of *Lindbladia effusa*, (Ehr.) Rost., var. *simplex*, Rex. It is of peculiar interest, however, from the fact that in the upper part of the sporangia, not only are the plasmodic granules arranged in a reticulate manner, but the wall itself shows, here and there, large, rounded perforations, thus emphasizing the peculiar relationship between the two genera *Lindbladia* and *Cribraria*. (Pl. LXI, fig. 18.)

Trichia reniformis, Pk., Rep. XXVI, p. 76, 1873, and Rep. XLVI, p. 57, 1893. Both Lister and Macbride agree in referring this species to *Trichia contorta*, Rost. It is the form described by Lister as var. *genuina*, with few elaters, and those very irregularly cylindrical, short, either simply branched or forked, and marked usually with three indistinct spiral bands. (Pl. LXI, fig. 19.) Macbride draws a distinction between the three very similar forms, *T. inconspicua*, Rost., *T. contorta*, Rost., and *T. Iowensis*, Macbr., on the basis of differences observable in the elaters. These differences, however,

* Macbride (l. c., p. 131) describes the spores of *C. æqualis*, Pk. as "distinctly warted." This feature does not appear in my glycerine mountings from the type-specimen.

† Since writing the above, Mr. Hugo Bilgram, of Philadelphia, has called my attention to the striking similarity, in external appearance, between *Comatricha æqualis*, Pk. and *Stemonitis pallida*, Wing. This is certainly very marked; nevertheless I think they may be distinguished by the denser capillitium of the *Stemonitis*, its superficial net and its slightly smaller and redder spores.

appear to be rather developmental than specific. The character of the elaters in the *Trichiaceæ*, useful as it undoubtedly is as indicative of generic and even specific lines of demarcation, nevertheless can hardly be regarded as very stable. Species of *Hemitrichia* occasionally show the free elaters characteristic of the genus *Trichia*, and on the other hand forms normally provided with free elaters are sometimes found with the elaters combined into a network. Within the limits of a single species, or even of a single specimen, great variety in the markings of the elaters is often seen. In the small specimen of *T. reniformis*, Pk., which we are considering, some of the elaters are almost exactly like those of *Oligonema*, while others are long, well-developed, and show perfectly even and distinct spirals, approaching very closely in this respect Rostafinski's *T. inconspicua*. It does not seem advisable therefore, merely on the ground of variations in the character of the elaters, to distinguish, as separate species, forms otherwise so nearly identical as the three above mentioned, and I can but regard *Trichia reniformis*, Pk. (*T. contorta*, Rost., var. *genuina*, List.), *T. inconspicua*, Rost., and *T. Iowensis*, Macbr., as varieties of a single species characterized by sessile, subglobose or somewhat elongated sporangia, of a dark reddish or purplish-brown color, and provided with warted spores.

Oligonema flavidum, Pk. (*Perichæna flavida*, Pk.), Rep. XXVI, p. 76, 1873, and Rep. XXXI, p. 57, 1878. The genus *Oligonema* presents serious difficulties to the systematist, by reason of the varied and intergrading characters exhibited not only in different gatherings, but often in different portions of the same gathering. The type-specimen of the present species presents the following characters :

Sporangia densely aggregated in small, effused clusters, occasionally superimposed, 0.4–0.6^{mm} in diameter, globose or slightly elongated, sometimes cylindrical, clear golden yellow, shiny, smooth, or wrinkled above. Wall membranous, pale yellow ; inner surface minutely and densely punctate. Elaters scanty, simple or sparingly branched, 52–243μ long, irregularly cylindrical, with occasional bulbous swellings, short blunt spines, and minute warts, the whole surface very minutely and densely spinulose or punctate, tips rounded or bluntly pointed. Spores yellow, 13–15μ in diameter,* the surface marked with narrow, raised bands forming an almost complete network. (Pl. LXI, figs. 23 & 24.)

* The measurements of the spores, in this and the following cases, include the spore-border.

The specimen bears a strong resemblance in outward appearance to *Trichia affinis*, DBy. The punctation on the inner surface of the sporangium-wall is resolved by the $\frac{1}{12}$ Homog. Im. lens into minute bristle-like hairs which lie in groups appressed in various directions. (Pl. LXI, fig. 24.) Peck's reference to the spores as "echinulate" (Rep. N. Y. St. Mus. xxvi., p. 76) is evidently an error in observation.

The question is, is this specimen referable to *Oligonema nitens*, Rost.? Lister considers that it is; Macbride regards it as distinct, on the basis of the roughened elaters with no distinct rings or spirals. The two forms differ also in habit, *O. flavidum* having exactly the habit of a *Trichia*. The markings of the sporangium-wall in *O. flavidum* are peculiar, and at first sight seem distinctive, but the examination of a number of specimens of *O. nitens* show that they cannot be so regarded. A specimen of *O. nitens* collected at Cambridge, Mass., shows an almost smooth wall marked only with extremely delicate striæ; others are absolutely identical in this respect with *O. flavidum*. As to the markings on the elaters in the two species, they are, at least in the case of *O. nitens*, subject to considerable variation. The Cambridge specimen above referred to has perfectly smooth elaters with the exception that, in a few instances, the very tip shows a ring-like thickening; other specimens show elaters marked with very faint spirals and here and there a stout, blunt spine, but no rings. In no specimen which I have seen, however, do they show the very densely punctate surface seen in *O. flavidum*. In this connection, another specimen in Professor Peck's collection is of interest. It was collected at Granville, Ohio, and was placed provisionally with *O. flavidum*. In outward appearance it is even more like a *Trichia* than is the type-specimen of *O. flavidum*, the sporangia being columnar in shape (rarely globose), densely crowded in an effused patch, and of a clear pale yellow color. The wall shows the same markings noted in *O. flavidum*. (Pl. LXI, fig. 27.) The fairly abundant capillitium consists of long, mostly simple but sometimes branching elaters, with a few bulbous expansions and marked with faint spiral bands, occasional short, blunt spines, and minute scattered warts. (Pl. LXI, fig. 26.) The elaters of this specimen are thus seen to approach those of *O. nitens* in the faint spiral markings which they exhibit when highly magnified, while the minute scattered spines or warts which are characteristic of the specimen distinctly recall the similar, though more abundant, markings of the elaters of *O. flavidum*. In its general habit and the abundance of

its capillitium it presents even a more marked divergence toward the genus *Trichia* than does the specimen with which it is associated.

The spores of the Granville specimen are slightly smaller than those of either *O. nitens* or the type-specimen of *O. flavidum*;* this, however, is a slight and unimportant distinction. A most careful examination of these specimens and a comparison of them with many specimens of *O. nitens*, leads to the conclusion that the name *Oligonema flavidum* is worthy of retention as applied to specimens showing more or less the habit of the genus *Trichia* and provided with densely and very minutely spinulose elaters, although specimens may occur which, in the abundance of the capillitium and the indications of spirals on the elaters, are hardly distinguishable from members of the genus *Trichia*, while others may show an equally marked divergence toward *Oligonema nitens*.

Oligonema brevifila, Pk., Rep. XXXI, p. 42, 1889. In outward appearance the type-specimen of this species is almost indistinguishable from *O. flavidum*, Pk. The color of the sporangia is of a slightly browner tinge and the wall is of a duller lustre. Macbride founds a specific distinction between them on the ground that *O. brevifila* occurs "in broad effused patches" and *O. flavidum* "in small heaped clusters." This distinction is not apparent in the type-specimens, both being equally effused, with the latter, if anything, less heaped together than the former. Both occur on moss. The sporangium-wall of *O. brevifila* shows the inner surface marked with densely clustered, very minute, bristle-like, appressed hairs, as in *O. flavidum*. The spores of *O. brevifila* are slightly smaller (11.2–12μ) than those of *O. flavidum*. The only marked difference between the two is seen in the elaters. In *O. brevifila* they are extremely scanty, reduced in length and increased in thickness; in shape they are irregularly cylindrical or fusiform; they are marked with fairly distinct but crowded and irregular spiral bands, occasional short, blunt spines or warts, and minute scattered spinules. (Pl. LXI, fig. 25.) This rudimentary condition of the elaters is practically the only feature which distinguishes this form from the Granville specimen of *O. flavidum* above described. The length of the elaters surely affords very insufficient grounds for establishing specific distinctions either in this genus or in the genus *Trichia*, since, e. g., typical specimens of *Oligonema nitens* almost always show, among the normal, long elaters, a few

* The following are the spore-measurements of these three forms: *O. flavidum*, 13–15μ; *O. nitens*, 12–14.2μ; the Granville specimen, 10.5–12.7μ. In all other respects the spores are identical.

which are almost as much reduced in length as those characteristic of *O. brevifila.* The genus *Trichia* also, presents the same varying feature, it being not uncommon to find specimens of *T. affinis*, DBy., in which all of the elaters are thus reduced. Taking these facts into consideration, it seems quite impossible to regard *Oligonema brevifila*, Pk. other than as a variety of *O. flavidum*, Pk.

It may not be out of place here to record the fact that typical specimens of neither *Oligonema nitens* nor *O. flavidum* and its varieties, commented upon above, show characters which serve to unite them with the very beautiful form described by Mr. Morgan as *Calonema aureum.* The latter, it is true, bears a very close external resemblance to *Oligonema nitens*, nor can we overlook the fact, regarding the highly developed capillitium, that in the genus *Trichia* analogous forms occur in which the normally free elaters are combined to form a network; nevertheless the peculiar character of the sporangium-wall in *Calonema aureum*, marked with scattered, raised papillæ from which radiate countless fine veinlets, and the abundant, strongly developed capillitium marked with reticulate ridges, faint spirals and prominent rings and spines, are combined features practically wanting in the genus *Oligonema*, and serve to distinguish that species from any other at present known to us. (Pl. LXI, figs. 28 & 29.)

Arcyria macrospora, Pk., Rep. XXXIV, p. 43, 1881. Both Lister and Macbride agree in referring this species to *A ferruginea*, Saut., and examination of the type confirms their statements. The dark, reddish-brown, ovoid sporangia, the coarse capillitium-threads somewhat triangular in section and marked with anastomosing or transverse bands and spinous processes, the large, pale-reddish, minutely spinulose spores, and the beautifully reticulated cup, are characters applicable to no other species.

A somewhat peculiar effect is produced in this species upon treatment with dilute potassium hydrate. In reddish-brown specimens this color is rapidly dissolved out from the sporangium, capillitium, and spores, leaving them of a uniform pale yellow color; in specimens originally yellow or ochraceous in color, this is at first changed by the alkali to a reddish-brown and then dissolved out. This lack of stability in the coloring matter of this and some other species is also seen in the rapidity with which it fades when exposed to direct sunlight.

We are now in a position to sum up the results of the foregoing observations upon the species originally described by Professor Peck.

Of the thirty-two species retained among the Myxomycetes by that author, I have been obliged to recommend that three names be discarded on the ground of the insufficiency, for purposes of accurate identification, of the original descriptions, and of lack of type-material. These species are *Physarum ornatum*, *Physarum luteolum*, and *Didymium angulatum*. In the case of three species, viz., *Stemonitis Morgani*, *Comatricha subcæspitosa*, and *Comatricha longa*, the type-specimens were not accessible to me and I have, therefore, referred them doubtfully, relying upon the original descriptions and upon the fuller notes published by other observers. The remaining 26 species I have referred as follows, confirming in most cases the judgment of one or the other of the two leading authorities on the group, Mr. Lister and Professor Macbride.

Badhamia magna, Pk. =	Badhamia magna, Pk.
Craterium obovatum, Pk. =	" rubiginosa, (Chev.) Rost.
Physarum albicans, Pk.	
" " var. subroseum, Pk.	= Physarum globuliferum, (Bull.) Pers.
" atrorubrum, Pk. =	" pulcherrimum, Berk. & Rav.
" inæquale, Pk. =	" lateritium, (Berk. & Rav.) Rost.
" pulcherripes, Pk. =	" Ravenelii, (Berk. & Curt.) Mass.
" citrinellum, Pk. =	" citrinellum, Pk.
" flavidum, Pk. =	" " "
Fuligo ochracea, Pk. =	Fuligo ochracea, Pk.
Physarella mirabilis, Pk. =	Physarella oblonga, (Berk. & Curt.) Morg.
Diderma flavidum, Pk. =	Physarum contextum, Pers.
Chondrioderma crustaceum, Pk. =	Chondrioderma globosum, (Pers.) Rost.
Diderma farinaceum, Pk. =	" spumarioides, (Fr.) Rost.
Diachæa splendens, Pk. =	Diachæa splendens, Pk.
" subsessilis, Pk. =	" subsessilis, Pk.
Didymium oxalinum, Pk. =	Physarum cinereum, (Batsch) Pers.
" connatum, Pk. =	" nephroideum, Rost. var. globosum.
" eximium, Pk. =	Didymium nigripes, (Lk.) Fr.
Stemonitis herbatica, Pk. =	Stemonitis ferruginea, Ehrenb.
Comatricha æqualis, Pk. =	Comatricha nigra, (Pers.) Schroet.
Perichæna cæspitosa, Pk. =	Lindbladia effusa, (Ehr.) Rost. var. simplex, Rex.
Trichia reniformis, Pk. =	Trichia contorta, (Ditm.) Rost.
Oligonema flavidum, Pk. =	Oligonema flavidum, Pk.
" brevifila, Pk. =	" flavidum, Pk. var. brevifila Pk.
Arcyria macrospora, Pk. =	Arcyria ferruginea, Saut.

Agricultural Experiment Station,
New Haven, Conn.

EXPLANATIONS OF PLATES.

Plate LX.

Fig. 1. *Badhamia magna*, Pk. Capillitium and spores. ×330.
Fig. 2. The same. Spores. ×680.
Fig. 3. *Badhamia hyalina*, Berk. Capillitium. ×330.
Fig. 4. The same. Spores. ×330.
Fig. 5. The same. Spores. ×680.
Fig. 6. *Badhamia utricularis*, Berk. Spores. ×330.
Fig. 7. The same. Spores. ×680.
Fig. 8. *Physarum albicans*, Pk. Sporangium showing columella, portion of capillitium, and rounded bodies within the stalk at the base. ×70.
Fig. 9. The same. Spores. ×680.
Fig. 10. *Chondrioderma crustaceum*, Pk. Spores and spherical lime-granules from the outer wall. ×680.
Fig. 11. The same. Portion of capillitium. ×680.
Fig. 12. *Chondrioderma globosum*, Rost. Portion of capillitium. ×680.
Fig. 13. The same. Spores and spherical lime-granules from the outer wall. ×680.
Fig. 14. *Chondrioderma spumarioides*, Rost. Spores and spherical lime-granules from the outer wall. ×680.
Fig. 15. The same. Portion of capillitium. ×680.
Fig. 16. *Didymium eximium*, Pk. (No. 2493 of Ellis & Everhart's N. Amer. Fung.) Upper part of stalk, columella, and persistent bases of capillitium-threads in optical section. ×70.
Fig. 17. The same. Part of columella and capillitium, and five spores. ×330.

Plate LXI.

Fig. 18. *Licea cæspitosa*, Pk. Upper portion of sporangium-wall, showing perforations. ×330.
Fig. 19. *Trichia reniformis*, Pk. Elaters and spores. ×330.
Fig. 20. *Diachæa subsessilis*, Pk. Spores. ×680.
Fig. 21. *Diachæa splendens*, Pk. Spores. ×680.
Fig. 21*a*. The same. Single spore, showing compound tubercles. ×1000.
Fig. 22. *Diachæa elegans*, Fr. Spores. ×680.
Fig. 23. *Oligonema flavidum*, Pk. Elaters and spores. ×680.
Fig. 24. The same. Part of sporangium-wall. ×680.
Fig. 25. *Oligonema brevifila*, Pk. Elaters and spores. ×680.
Fig. 26. *Oligonema flavidum*, Pk. (Specimen from Granville, Ohio.) Elaters and spores. ×680.
Fig. 27. The same. Part of sporangium-wall. ×680.
Fig. 28. *Calonema aureum*, Morg. Capillitial thread and spores. ×680.
Fig. 29. The same. Part of sporangium-wall. ×680.

X.—The Air-breathing Mollusks of the Bermudas.

By Henry A. Pilsbry.[1]

The land-snail fauna of the Bermudas is one of considerable interest from the isolation of the islands and their typical "oceanic" character. Their small extent and low altitude have not favored the development of a rich fauna, and in 1852, the date of the first list, some exotic snails had already become established there. Colonization proceeded until now the immigrants outnumber the original Bermudians in the roll of Stylommatophores.

Origin of the Bermuda Fauna.

The fauna of air-breathing mollusks of the Bermudas is divisible, in respect to origin, into three groups of forms.

(*a*) Autocthonous species, peculiar to the islands.
(*b*) Drift waifs from the West Indies.
(*c*) Species imported by the agency of man.

The first group includes a single *Thysanophora* (*hypolepta*) and one *Helicina* (*convexa*), both of Antillean type, and the genus *Pœcilozonites* with four species and several varieties.[2] The relation-

[1] This paper is based upon the collection made by Professor Verrill and party in 1898, that of Professor Heilprin's class who visited Bermuda in 1888, that of Robert Swift, and specimens from the collections made by Thomas Bland and C. B. Adams. Professor Verrill has added the results of his personal observations on many species, greatly increasing the value of the study.

[2] The species are *P. bermudensis*, *nelsoni*, *reinianus* and *circumfirmatus*. The genus *Pœcilozonites* was supposed by its founder to include the recent *Helix bermudensis* and the German lower Miocene *Helix imbricata* Braun. In a former paper on Bermudian Helices I had occasion to show that several other Bermudian species belong to *Pœcilozonites*, and I would here record my belief that in bringing a European Miocene species into the Bermudian group, Dr. Boettger is only chasing an ignis fatuus. The pursuit of false lights has led most of the Germans who write on Helices into a maze of quagmires. Whether dealing with fossil or recent forms, their ideas on classification, and consequently on zoögeographic and palæontologic history also, are so hopelessly astray that the only path to redemption is for the young men to break away from the blind leaders of the blind, and seek solid footing.

ships of this genus are with *Gastrodonta*, a genus of the eastern United States, which comprises species with an internal lamella, as in *P. circumfirmatus*, and others without it, as in the other *Pœcilozonites*. The very peculiar genitalia leave no doubt as to the alliance between *Gastrodonta* and *Pœcilozonites*. No closely allied forms are known from the Antilles or from Europe. It appears therefore that the oldest element in the Bermudian Pulmonate fauna is distinctively North American, while all the rest of the endemic fauna is Antillean.

The single *Veronicella* of the fauna has, so far, not been found elsewhere, but it may yet prove to be exotic.

The second group of forms consists of species common to Bermuda and the Antilles. Omitting the *Auriculidæ*, *Siphonariidæ*, *Onchidiidæ*, and *Truncatella*, which from their littoral habits and tolerance of salt water have exceptional facility in over-sea journeying, we find some eight species of truly terrestrial forms which apparently reached Bermuda by natural means of transportation, and are not modified from the parent stocks.

Thysanophora vortex, Greater Antilles, Bahamas, Southern Florida.

Polygyra microdonta, Bahamas.

Zonitoides minusculus, Greater Antilles ; whole United States.

Pupa (*Bifidaria*) *servilis*, Cuba, Bahamas.

" " *rupicola*, Cuba, Florida.

" " *jamaicensis*, Jamaica.

Pupoides marginatus, Greater Antilles ; U. S.

Succinea barbadensis, Barbados, and under various names, some other islands.

The small or minute size of all these is noteworthy ; the *Succinea* being the largest species which has been able to journey so far over sea.

The whole series of littoral air-breathers (*Auriculacea* and *Truncatella*) likewise belongs to the Antillean group, the species being in all cases either identical with West Indian forms, or but very slightly modified.

A third element of the Bermudian fauna consists of those forms which have probably been transported thither by human agency ; and as the date of introduction of the several forms is a matter of some interest to those who may hereafter study their variation in a new environment, I give below the data for each species so far as practicable.

Species.	When first collected or reported.	Original patria.	Present occurrence.
Helicella ventricosa	1852. T. Prime	Europe	Very abundant.
Eulota similaris	1889. T. H. Aldrich	East Indies	Abundant
Vallonia pulchella	1876. J. M. Jones 1881. Thos. Bland	Europe, N. America	Not recently taken.
Polygyra appressa	1876. J. M. Jones	Virginia, Tenn.	In some abundance.
Rumina decollata	1888. Heilprin, Stone, *et al.*	Southern Europe	Very numerous.
Subulina octona	1881. T. Bland	West Indies	Abundant.
Opeas octonoides	1888. Heilprin party	West Indies, etc.	?
" swiftianum	" " "	St. Thomas, etc.	?
Ennea bicolor	" " "	East Indies	One shell taken in '88.
Cæcilioides acicula	1861. T. Bland	Europe	No recent record.
Limax flavus	1898. A. E. Verrill	"	----------
Agriolimax lævis	1873. 'Challenger' Ex.	"	Not again reported.
Amalia gagates	" " "	"	In some numbers.
Physa acuta	1880–'88. G. Brown Goode	"	Not again reported.

From the data supplied by Prof. Verrill's expedition and that of Prof. Heilprin it seems that *Vallonia pulchella*[1], *Cæcilioides acicula*, *Agriolimax lævis*, and *Physa acuta* rest upon single records now nearly twenty years old, and they may not have permanently colonized; but as none of them are conspicuous forms, and no special collectors of land shells have sought for them, the merely negative evidence is inconclusive. Probably all the others are well established colonists.

The abundance of European forms corresponds with the preponderance of European shipping in former times. The Indian or East Indian forms were probably brought with living plants for the Botanical Garden; while the single North American form, *P. appressa*, may have had a similar advent. How the *Physa* found its way to Bermuda is problematic,[2] as the cistern in which it occurred is one of the roofed rain-water catchment reservoirs commonly in use in the islands.

It is somewhat peculiar that *Helix nemoralis*, *lactea*, and *aspersa* have not yet established themselves in Bermuda, as they are usually among the first emigrants from the old country, like the slugs.

[1] This species was recorded both by J. M. Jones, 1876, and by Bland, 1881, independently, but as Jones and Bland were in correspondence at that time (see p. 508), it is quite probable that it was collected only by Jones, who resided in the Bermudas during many years in the winter and spring season and made large collections there.—(A. E. V.)

[2] It may have been introduced with the cultivated water lilies.—(A. E. V.) See note, p. 503.

It is obvious that in dealing with certain Antillean species, such as *Opeas*, it is not possible to rigidly discriminate between those introduced by natural means and those imported by man. The earlier faunal lists are our chief dependence in such cases. The same difficulty is encountered in deciding upon the primitive flora of the islands, and of course attends all work on insular faunas or floras at the present day.[1]

Oceanic characteristics.—The foregoing data expose the truly "oceanic" nature of the fauna, which is a peculiarly *disharmonic* assemblage, to use Baur's expressive term. The endemic element (*Pœcilozonites*) undoubtedly long antedated the other forms, as its generic divergence and strong specific differentiation indicate. In all probability it was derived from the eastern United States by some rarely efficient means of transport. The remaining forms are all Antillean in their affinities, and probably a drift or flotsam fauna. But the Antillean element by itself is not harmonic, for the absence of *Cerion*, *Urocoptidæ*, belogonous or epiphallogonous Helices, and cyclostome operculates, all eminently characteristic of the West Indian faunas, betrays the hand of what we call chance, or the rigorous selective action of an over-sea journey, in the Bermudian assemblage.

List of Species.

Family **HELICIDÆ.**

Helicella (Cochlicella) ventricosa (Drap.).

First reported by Temple Prime in 1852. It has been noticed by all later collectors, and it is now exceedingly abundant.

It is common under the scales of cycad trunks, and in crevices of bark and knot holes of other trees. Also under the bark of fallen trees.—(Cook.)

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[1] As early as 1615–20, or immediately after the first settlement, expeditions were sent to the Bahamas to introduce various useful tropical plants in growing condition, as well as seeds. Among the plants enumerated as introduced at that time and with which snails and insects may have been introduced, were the pineapple, papaw, sugar-cane, banana, plantain, cassava, orange, lemon, and many others.

At about the same time various useful plants were also introduced from Virginia and from England. "Vines and cuttings of vines" were sent from England about 1616.

Eulota similaris (Fér.).

First reported by Hon. T. H. Aldrich, in 1889 (Nautilus III, 9) and found in some abundance by Mr. T. H. Montgomery some years later. The specimens collected by Prof. Verrill's party[1] are remarkable for their great solidity, elevated spire and distant faint spiral lines. The genitalia, however, are typical for the species. The kidney is very long and band-like, as in *Polygyra*, being double the length of the pericardium, and over half that of the lung.

This species has been widely distributed by commerce from an oriental center, and has long been known from Barbadoes, Rio de Janeiro, Havana, etc.

Vallonia pulchella (Müll.).

Recorded by Jones, 1876, and in Bland's list of 1881. The specific identity of Bermudian specimens has been confirmed by Dr. V. Sterki, from examples in U. S. Nat. Mus. (Proc. A. N. S., Phila., 1893, p. 278).

Thysanophora vortex (Pfr.).

PLATE LXII, FIGURES 1*a*, 1*b*.

An abundant Bermudian species, taken by many, if not all, collectors.

Common under stones on the larger islands. A few dead shells were found on Bailey Bay Island (Cook).

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[1] This party consisted of Professor A. E. Verrill, Yale University, with M. C. Cook, W. E. Porter, and C. S. Verrill, students in the Sheffield Scientific School of Yale University. They were in Bermuda during April and May, 1898. Much more attention was paid by this party to the study of marine zoölogy than to terrestrial forms. Mr. Cook, however, devoted considerable time specially to the land snails, and to his devotion to this part of the work the relative completeness of the collection is mostly due. It was not practicable, however, to visit all parts of the islands, nor to spend much time in searching for rare and minute species. Doubtless a thorough search, especially in the swampy districts, would reveal a number of additional species. Some of the rarer forms, especially of slugs, were obtained by collecting in the night, with a lantern, when large numbers of snails and slugs could be found creeping on the stone fences, which are all built of limestone and often whitewashed. The owners of the fences sometimes complain that the snails eat the mortar from between the stones and thus damage the walls. Several species occur in vast numbers, and some of them, especially *Rumina decollata*, are quite injurious to garden vegetables and to fruit.—(A. E. V.)

Thysanophora hypolepta (Shuttl.; Pils.).

PLATE LXII, FIGURES 2*a*, 2*b*.

Helix (*Microphysa*) *hypolepta* Shuttl., Pilsbry, Proc. A. N. S. Phila., 1889, p. 82, pl. iii, f. 6, 7, 8.

This minute species has the size of *Zonitoides minusculus*, but differs radically from that species in form, especially in the outline of the aperture. It could not certainly be known from Shuttleworth's note whether he had this species or the broadly umbilicated variety of *Z. minusculus*, but the tradition preserved on labels by Bland fixes its identity. The species is apparently peculiar to Bermuda. First recorded by Jones, 1876. It was also recorded by C. B. Adams and T. Bland, but seems to have escaped later collectors.

Polygyra microdonta (Desh.).

PLATE LXII, FIGURE 3.

Found by Robert Swift in 1852, and by all later naturalists who collected land shells. It is distinguished from the Florida wheel-shaped *Polygyras* by its very much finer striation above. It occurs also in the Bahamas. One of the most abundant Bermudian species.

It is one of the few species found on Shelter Island and various small uninhabited arid islands. It occurred abundantly under stones on the main island, near the Causeway.—(Cook.)

Polygyra appressa (Say).

First recorded from Bermuda by Jones, 1876, and by Bland in 1881. It still flourishes there, as the specimens taken by Professor Verrill's party attest. These are rather small (diam. 13–14^{mm}) and strongly ribbed, belonging to the var. *sculptior* Chadw., which ranges from Virginia westward. There cannot be much doubt that the species was imported from the United States. Mr. J. M. Jones, 1876, knew it from but one locality, near St. Georges. Now common.

It was found abundantly in an old stone wall near the Post Office at Bailey Bay.—(Cook.)

Family **ACHATINIDÆ.**

Rumina decollata (L.).

This south European species has become extremely abundant over the cultivated portion of the main island, doing damage to fruit and vegetables. It was first reported from the island in 1888. It was not recorded by Jones in 1876.

I was told that it was abundant in the vicinity of Hamilton several years before it spread to Bailey's Bay and other parts of the main island. It is not found on the smaller islands.—(A. E. V.)

Subulina octona (Chemn.).

Plate LXII, Figure 4.

Reported from Bermuda by Bland in 1881, and found by Aldrich, Heilprin, and by Verrill's party. Common under stones.—(A. E. V.)

Opeas octonoides (C. B. Ad.).

Several small specimens taken by Prof. Heilprin's party in 1888.

Opeas swiftianum (Pfr.).

Plate LXII, Figure 5.

Twenty specimens taken by the party of 1888. It is known from St. Thomas, St. John, Porto Rico, and Vieque. Whether this and the preceding two Antillean species were introduced by natural means or by human agency is not known with certainty, but their recent detection strongly indicates the latter alternative.

Cæcilioides acicula (Müll.).

Reported by Bland in 1861, and by Jones in 1876, but not found by later collectors, so far as I know.

Family **PUPIDÆ.**

Mr. M. C. Cook of our party notes that most of the Pupidæ in our collection were obtained from under stones in a field opposite Mr. Seon's residence at Bailey Bay, where they were abundant. Some dead ones were found on Bailey Bay Island and on Trunk Island in Harrington Sound.—(V.)

Pupa (Bifidaria) servilis Gld.

Plate LXII, Figure 6.

This is *Pupa pellucida* of Bland's list, and probably in part *Pupa bermudensis* of Prime, though the latter may have been based upon the following species, or both. Originally described from Cuba, the species is known from various West Indian islands. Alt. 2.7^{mm}.

Pupa (Bifidaria) jamaicensis C. B. Ad.

PLATE LXII, FIGURE 7.

Described as Jamaican, but probably occurs throughout the Greater Antilles. It differs from *P. servilis* in having the middle tooth of the outer lip situated decidedly deeper than its fellows, not prominent as in *servilis*. There is a more or less developed ridge or crest behind the outer lip. Alt. 2.3^{mm}.

Pupa barbadensis Pfr. has been reported by Bland from Bermuda, but specimens so labelled in the collection of the Acad. Nat. Sci., Phila., prove to be *jamaicensis*.

Pupa (Bifidaria) rupicola Say.

PLATE LXII, FIGURE 8.

Shell resembling *P. servilis* in size and form, perforate, pale brownish corneous, striatulate, composed of fully 5 convex whorls, those above tapering to a very obtuse apex ; the last whorl widest, expanding to form a narrow whitish crest very close behind the lip. Aperture oval-rounded, obstructed by 5 denticles : the parietal lamella with bilobed crest, but with no other indication of its composite structure; columellar lamella strong, entering ; sub-columellar very small, short, low, and well immersed; two palatal plicæ immersed beyond the position of the external crest, the upper one very small, the lower deeper immersed, and slender. Outer lip expanded, enormously thickened within by a white callus or flange, which is weakly emarginate above, and a little grooved on its flattened face.

Alt. 2.4 ; diam. 1 ; longest axis of aperture .84^{mm}.

Bermuda. This species was taken by Prof. Heilprin in 1888. It differs from the allied forms chiefly in the conspicuous thickening of the peristome by a white internal callus or flange. The same form occurs in Cuba and Florida, though there it has a less thickened lip. I have considered it well to figure and redescribe Say's species because the *P. rupicola* of Binney's works is *P. procera* Gld.

Pupoides marginatus (Say).

PLATE LXII, FIGURE 16.

Recorded under various names by Bland and others. Specimens taken by Prof. Verrill's party are practically typical. It is the *Pupa fallax* of most American writers. Recorded by Jones, 1876, as rare.

Bailey Bay in field under stones.

Family **STREPTAXIDÆ.**

Ennea bicolor (Huttou).

A single specimen of this little traveller was taken by Prof. Heilprin's class, and is now first recorded. Originally East Indian, the species has now been scattered widely in the Eastern Hemisphere. It has been recorded from Trinidad, and Mr. S. N. Rhoads collected specimens near Havana in 1899.

Family **ZONITIDÆ.**

This family contains the only genus of land snails peculiar to Bermuda, *Pœcilozonites*. The relationships of this group are clearly with the genus *Gastrodonta*, which is confined to the eastern United States. The generic synonymy, which is somewhat extensive, has been given in full in Proc. Acad. Nat. Sci., Phila., 1889, p. 86. The species are as follows:—

a. No lamina within the mouth.
  b. Umbilicus narrow; columella making an angle with the basal lip; shell strong and solid. *P. bermudensis*, *P. nelsoni*.
  b^1. Umbilicus wide; peristome evenly arcuate below; shell thin, radially flammulate. *P. reinianus*.
a^1. A lamina revolving within the aperture, on the outer wall. *P. circumfirmatus*.

Pœcilozonites bermudensis (Pfr.).

Pilsbry, Proc. Acad. Nat. Sci. Phila., 1888, p. 289; 1889, p. 85.

This is one of the most abundant and the largest living species. While usually banded with brown, it is sometimes plain yellowish; and the young are often prettily flammulate.

It occurred under stones and old logs, and in walls; generally distributed.—(V.)

The *Helix ochroleuca* of Pfeiffer's monograph (vol. i, p. 80) described from Bermuda, looks like a narrowly umbilicate *P. bermudensis* with the periphery rounded, not carinated. If really Bermudian, it probably is a distinct species of *Pœcilozonites*, which will require a new name when rediscovered, as it is not the *ochroleuca* of Férussac.

Helix ochroleuca Férussac (Histoire, pl. 30, f. 1) is identical with the later *Pachystyla rufozonata* H. Ad. (*cf.* Nevill, Journ. Asiat. Soc. Bengal, 1875, p. 104), a Mauritian species.

Pœcilozonites nelsoni (Bld.).

Hyalina nelsoni Bld., Ann. Lyc. N. H. of N. Y., xi, 1875, p. 78.
P. nelsoni Pilsbry, Proc. A. N. S., Philad., 1888, p. 290, pl. xvii, f. J, K, L.
P. nelsoni v. Mart., Sitzungsber. Ges. Nat. Freunde, Berlin, 1889, p. 201.

This species was found by Mr. T. M. Jones in the "stalagmitic conglomerates in caverns at Tucker's Town." Professor Heilprin procured specimens from the same locality, and probably Beyrich's specimens, recorded by Von Martens, were from the same place.

It occurs at numerous localities imbedded in the softer æolian limestone, often in large numbers. At Bailey's Bay Island I obtained specimens from a ledge exposed only at low tide.—(A. E. V.)

Bland's type measured alt. 19,[1] diameters 37 x 34mm. Four specimens before me measure: alt. 21½, diam. 33; alt. 26, diam. 40; alt. 30, diam. 33; and alt. 30, diam. 30mm. The last three are exceptionally coarse in sculpture, almost or entirely free from carination at the periphery, and have about 9 whorls.

Rarely a specimen of *P. bermudensis* is found with much the contour of the more elevated forms of *P. nelsoni.*

Pœcilozonites reinianus (Pfr.).

Helix reiniana Pfeiffer, Malak. Bl., xi, 1863, p. 1.

Pilsbry, l. c., p. 290, pl. xvii, f. I, 1888. Also 1889, p. 85, pl. iii, f. 12, 13 (var. *goodei*).

This species is more broadly umbilicated than *P. circumfirmatus*, and has no internal lamina. The variety *goodei* Pils. has a still wider umbilicus and is quite flat above.

This species was not found by our party. Our specimens were presented to us by Miss A. Peniston.—(V.)

Pœcilozonites circumfirmatus (Redf.).

Helix circumfirmata Redfield, Ann. Lyc. N. H. of N. Y., vi, p. 16.
Pilsbry, Proc. Acad. N. S., Phil., 1888, p. 291, pl. xvii, f. F, G, H.
Helix discrepans Pfr., Malak. Bl., 1864, p. 1.
? *Helix ptychoides* Prime, Bermuda Almanac, 1852 (*nomen nudum*).

PLATE LXII, FIGURES 9, 9*a*.

Peculiar by the lamina within, reminiscent of the allied genus *Gastrodonta.* It varies from the thick typical form to a depressed

[1] The alt. was probably measured by Pfeiffer's method, which is more correctly the length of the central axis, not of the whole shell.

form which has been called *Helix discrepans* by Pfeiffer. The abbe A. Vathelet found a clear corneous race in one locality, though where I do not know ; and this is what I named var. *corneus*.

Common under stones at Bailey Bay.—(Cook.)

Zonitoides minusculus (Binn.).

PLATE LXII, FIGURE 17.

A number of specimens collected by Prof. Verrill's party show some variation in the size of the umbilicus, as in those from Florida; and in some it is quite as wide as in the form called var. *alachuanus* by Dall. Some specimens before me were taken many years ago by Prime, and it is probably to be reckoned as indigenous. It is a common and wide-spread North American and West Indian species.

Common in the yard of a house at Bailey Bay, under stones. (Cook.)

Family **LIMACIDÆ.**

Limax flavus L.

Typical specimens of this European species were taken by Prof. Verrill's party. It is not uncommon in Philadelphia and some other Eastern cities, but has not hitherto been reported from Bermuda.

Under stones. Also taken at night, by lantern light, on stone fences.—(A. E. V.)

Agriolimax lævis (Müll.).

Cockerell, Journ. of Malacol., vi, p. 3 (1897).

A young specimen was found by Prof. Cockerell among *Amalia gagates* collected by the naturalists of the 'Challenger' in 1873, and is now in the British Museum.

Amalia gagates (Drap.).

E. A. Smith, Proc. Zool. Soc., Lond., 1884, p. 276. Cockerell, Ann. Mag. N. H. (6), vii, p. 328 (1891).

Taken by the 'Challenger' naturalists in 1873, by Mr. T. H. Aldrich in 1889, and by Prof. Verrill in 1898. It would therefore seem to be firmly established in Bermuda. Easily known by the very dark color and keeled back.

Found at night creeping on the stone fences. Taken while hunting snails with a lantern. Occasionally found under stones.—(A. E. V.)

Family **SUCCINEIDÆ.**

Succinea barbadensis Guild.

Guilding, Zoological Journal, iii, p. 532, Suppl., pl. 27, f. 4–6.
S. bermudensis Pfr., P. Z. S., 1857, p. 110; Monographia, iv, p. 817.

Variable in length of the spire, but I am unable to recognize more than one species in a series of several hundred shells collected by Swift, Bland, Vathelet, Heilprin, and Verrill.

The several *Succineas* reported from Bermuda—*S. margarita* Pfr., *S. fulgens* Lea, and *S. bermudensis* Pfr.,—seem to me to be merely varying identifications of a single species, the *S. bermudensis* of Pfeiffer. On comparing with *S. barbadensis* Guilding, from Barbados, I must agree with Mr. Smith[1] that there is no difference between the shells; but the shells of this genus are peculiarly uncharacteristic, species of different regions frequently resembling each other. Probably the soft anatomy will give better specific characters, as in the slugs.

Taken in large numbers in the crevices of the bark of a large tree in Miss Peniston's grounds.—(Cook.)

Family **VERONICELLIDÆ.**

Veronicella schivelyæ (Pilsbry).

Vaginulus schivelyæ Pils., Proc. Acad. Nat. Sci., Phila., 1890, p. 297, p. 5, f. 6, 7, 8.

Two specimens were taken by Miss Mary Schively, a member of Professor Heilprin's class, in 1888. A few years later I was told that the species had become abundant and destructive to vegetables. Professor Verrill obtained a number of specimens. Owing to its nocturnal feeding habits, it is not likely to be conspicuous to the casual visitor.

In coloration it varies from heavily blotched in two bands along the back, to mere indications of the bands. While it would seem likely that the species is an introduced one, I have been unable to identify it with any of those described from other regions.

Nearly all of our specimens were obtained, with many other pulmonates, by examining the whitewashed surfaces of the stone fences and outhouses by the light of a lantern, late at night. The largest were 8 to 10 inches long when extended.—(A. E. V.)

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[1] Proc. Malacol. Soc., Lond., i, p. 321.

Family **ONCHIDIIDÆ.**

Onchidium floridanum Dall.

O. floridanum Dall, Proc. U. S. Nat. Mus., 1885, p. 288.
O. transatlanticum Heilprin, Proc. Acad. Nat. Sci., Phila., 1888, p. 327, pl. 16, f. 4, 4a.

Originally described from Knight's Key, Florida, where Hemphill collected it. Professor Heilprin found the types of *O. transatlanticum*, which seems to me to be completely synonymous with *floridanum*, "in a rock hollow on the north shore just beyond Wistowe, near Flatts Village."

It was very abundant at Bailey's Bay, near Mr. Seon's house, on the rough eroded ledges, at and just below high-tide mark. Its dark olive green color agrees so well with the stains on the rocks that it is very inconspicuous.—(A. E. V.)

Family **PHYSIDÆ.**

Physa acuta Drap.

Specimens of this common European species were collected by Mr. G. Brown Goode, in a fresh-water tank, several years ago. All the freshwater on the island is rain water storage, so the means by which this species reached the tank is a mystery. I am indebted to Prof. Dall for the opportunity of seeing this species.

Water lilies and other aquatic plants have been cultivated in the gardens (see Lefroy's List of Plants, Bull. Nat. Mus., xxv). It may have been introduced with such plants, or with goldfish that are now naturalized in the brackish ponds.—(A. E. V.)

Family **AURICULIDÆ.**

Pedipes mirabilis (Mühlf.).

Typical specimens of all ages taken by Heilprin. It is readily distinguished from the next species by the blunt tooth within the outer lip of adults, with a ridge running parallel to the peristome below it. Length 4–5^{mm}.

Pedipes tridens Pfr.

Plate LXII, Figure 10.

Originally described from Bermuda, from Redfield's collection, some of whose specimens are before me. Also collected by Profes-

sors C. B. Adams, Heilprin, and Verrill's party. It is much smaller than *P. mirabilis*, more oval than the young of that species, and never develops a tooth within the outer lip. Recorded by Jones, 1876.

Plecotrema cubense Pfr.

PLATE LXII, FIGURE 11.

Taken by Heilprin's party in 1888 and by Prof. Verrill's party in 1898 (No. 12,046). The specimens agree with those from Cuba.

Alexia myosotis bermudensis Pfr.

Scarcely distinct from the European and New England *myosotis*, but on the average differing in the absence or small size of the upper parietal fold, there being usually but two folds on the columellar side of the mouth, and none within the outer lip. Occasional specimens, however, have three folds. Those before me were collected by C. B. Adams, Heilprin's party, Prof. Verrill's party, and others, so that it is apparently an abundant species. Recorded by Jones, 1876.

Our examples were mostly collected on the edges of a small pond, near the Post Office at Bailey's Bay.—(V.)

Melampus flavus Gmel.

Taken by Heilprin's party. It is easily known by the very low position and subvertical direction of the columellar fold.

Melampus redfieldi Pfr.

Scarcely, if at all, to be distinguished from the prior *M. gundlachi* Pfr., but not attaining so large a size. It was originally described from the Bermudas, and has been taken there by Robert Swift, Thomas Bland, and the parties conducted by Professors Heilprin and Verrill.

Melampus gundlachi Pfr.

Three specimens, typical of this form, were sent me many years ago by Mr. C. T. Simpson ; and Mr. E. A. Smith identifies it among the 'Challenger' shells. It seems to intergrade in Florida with *M. coffea* L. Dall, in his revision of the Auriculacea, has mistaken it for *M. flavus*, which is really quite a distinct thing.

Family **SIPHONARIIDÆ.**

Siphonaria brunnea Hanley.

P. Z. S., 1858, p. 24. *S. picta* Sow. and *S. alternata* Say, of Heilprin's list.

Differs from *S. alternata* in the more unequal ribs, but is perhaps only a variety of that species. *Cf.* also *S. picta* D'Orbigny. This form is of course exclusively marine, and introduced here merely to complete the list of air-breathing mollusks.

Abundant on rocks between tides.—(A. E. V.)

An undescribed species of *Siphonaria* was also taken. See a subsequent article by Verrill and Bush in this volume (p. 524).

Family **TRUNCATELLIDÆ.**

The species known from Bermuda may be determined by the following key:

a. No noticeable crest behind the outer lip.

b. Ribs close and numerous, regularly developed; alt. usually 6–7^{mm}. *T. caribæënsis.*

b^1. Ribs partially or wholly effaced on the convexity of each whorl; size usually smaller. *T. caribæënsis pulchella.*

a^1. A strong, continuous crest behind the basal and outer lips; alt. 4–5^{mm}.

b. Ribs fine and close, 25–30 on the last whorl. *T. bilabiata.*

b^1. Ribs strong and coarse, 13–15 on the last whorl. *T. clathrus.*

Truncatella caribæënsis 'Sowb.'; Reeve.

Plate LXII, Figures 14, 14*a*.

Typical specimens are in the collections made by Verrill and by Heilprin.

Truncatella caribæënsis pulchella Pfr.

The specimens before me were collected by Robert Swift and C. B. Adams, but they evidently found it in large numbers. Recorded by Jones, 1876.

Truncatella bilabiata Pfr.

Plate LXII, Figure 12.

Taken by Prof. Heilprin's class, and by Prof. Verrill's party. It is the strong-crested Floridian variety of the species, not the typical form, which occurs in Bermuda.

Truncatella clathrus Lowe.

PLATE LXII, FIGURE 13.

This coarse-ribbed and comparatively rare species was collected by both Verrill and Heilprin. It has hitherto been reported only from Porto Rico and St. Thomas.

Family **HELICINIDÆ.**

Helicina convexa Pfr.

PLATE LXII, FIGURES 15, 15*a*.

Abundant and taken by nearly all collectors. Evidently the *Helicina subdepressa* Poey of Jones, and *H. fasciata* of some early lists refer to this species. There seems scant justification for Angas' assertion that *H. convexa* is identical with *H. fasciata;* I consider it a well characterized species.

Bland reports *H. convexa* from Barbuda; but I cannot help thinking that either his identification or locality was wrong. It is probably peculiar to Bermuda.

Abundant under stones and in walls.—(V.)

BIBLIOGRAPHY.

All of the lists based on original material are noticed below. The older ones contain many erroneous identifications.

1852, 1859.—The Naturalist in Bermuda, by John Matthew Jones (London). Mollusca on pp. 106, 107.

This list is said to be compiled from one by Mr. Temple Prince (*sic*) published in the Bermuda Almanac for 1852. I have not seen the original list by Prime. The following air-breathing mollusks are enumerated.

Helix palludosa (Polygyra microdonta).
" microdonta (" ").
" ptychoides (Pœcilozonites circumfirmatus).
" selenina (Thysanophora vortex).
" bermudensis (P. bermudensis).
" sancta-georgiensis n. sp.
" somersetti "
Bulimus ventrosus (Cochlicella ventrosa).
Bulimus bermudensis n. sp.
" sandysii "
Pupa bermudensis " (Bifidaria sp.).
Helicina variabilis (H. convexa).
Succinea bermudensis n. sp. (S. barbadensis).
Truncatella aurea n. sp.
Auricula flava (Melampus sp.).

Many of the names of this list were evidently erroneous identifications; and the new species were never described under these names, with the exception of *Succinea bermudensis*. It is of value as showing that the fauna contained at least thirteen terrestrial species in 1852, only one of which, *Bul. ventrosus*, is known to be introduced. I have given in parenthesis the equivalents in modern nomenclature of such of the species as can be recognized. *Helix sancta-georgiensis* and *H. somersetti* may have been applied to *Pœcilozonites reinianus* and *Thysanophora hypolepta* or *Z. minusculus*. *Bulimus bermudensis* and *B. sandysii* were perhaps based upon species of *Opeas* or *Pupoides marginatus*, though it is likely that an American observer would have recognized in the latter a common United States species.

1860.—Bermuda: Its history, geology, climate, products, agriculture, commerce and government. By Theodore L. Godet, M.D. London; Smith, Elder & Co. Chapter XIV, "Shells" includes Crustacea and Mollusca. Under the head *Pulmonea* (p. 224–227) are enumerated *Limax cinereus*, *Testacella haliotidea*, *Vitrina pellucida*, *Helix concava* and *hortensis*, *Pupa chrysalis*, *Clausilia papillaris*, *Bulimus lubricus*, *Achatina columaria*, *Succinea bermudiensis*, *Limnæa auricularia*, *Physa fontinalis*, *Auricula midæ* and *Ancylus rivularis*. With the exception of *Succinea bermudiensis*, which is proposed as a new species, there is no reason to believe that any of these identifications were based upon Bermudian specimens. The list might have been compiled in Bedlam, and is introduced here merely as a curiosity, and for the sake of bibliographic completeness.

1861.—Catalogue of a collection of mollusks from Bermuda, by H. B. Tristram. Proc. Zool. Soc., Lond., 1861, pp. 403–405.

This collection was made by Col. Freeman Murray, one time Governor of the Bermudas.

The greater number of species listed are marine forms, but the following pulmonates are given :

Helix bermudensis.
" circumfirmata,
" microdonta Dh.
" paludosa Say.
Bulimus ventricosus Dr.
Succinea ——— ?
Helicina variabilis Ad.
Melampus coffea.
" fasciatus Chemn.
" oblongus Pfr.

1861.—On the Geographical Distribution of the Genera and Species of Land Shells of the West India Islands; with a Catalogue of the species of each island, in Ann. of the Lyc. of Nat. Hist of N. Y., vii, p. 351. By Thomas Bland.

This is the first list of Bermudian shells by an experienced conchologist. It was based upon specimens collected by C. B. Adams, Robert Swift, Temple Prime, T. Bland and others.

Helix bermudensis Pfr.
" circumfirmata Redf.
" microdonta Dh.
" ochroleuca Fér. ?
" vortex Pfr.
Bulimus nitidulus Pfr.
" ventrosus Fér.
Achatina acicula Müll.
Pupa jamaicensis C. B. Ad.
" pellucida Pfr.
Succinea bermudensis Pfr.
" fulgens Lea.
" margarita Pfr.
Truncatella subcylindrica Gray.
Helicina convexa Pfr.

This list was the basis of the later ones of Kobelt and Fischer.

1864.—Contributions to the Nat. Hist. of the Bermudas, Part i, Mollusca, by T. Matthew Jones, Halifax, N. S., 1864. Air-breathing forms on pp. 8, 9.

Helix bermudensis Pfr.
" circumfirmata Redf.
" microdonta Desh.
" ——— ?
Succinea texasiana Pfr.
" ——— ?
Bulimus ventrosus Fér.
Pupa ——— ?
Melampus redfieldii Pfr.
" flavus Gm.
Helicina subdepressa Poey.

1876.—The Visitor's Guide to Bermuda, with a Sketch of its Natural History. By J. M. Jones. Halifax, 1876. Land shells on pp. 138, 139.

The following twenty-six nominal species are enumerated. Those here marked with an asterisk are not included in the earlier lists.

The author (p. 436) acknowledges the assistance of Thomas Bland in the identification of the terrestrial and fluviatile shells.

Hyalina ochroleuca. Rare (=var. of next).
H. bermudensis. Very common.
H. " var. nelsoni. Semifossil.
*H. reiniana. Rare.
H. circumfirmata. Common.
*H. discrepans. Rare (= var. of last).
Helix vortex. Not common (=*Thysanophora*).
H. hypolepta. Rare (=*Thysanophora*).
*H. pulchella. Not common (= *Vallonia*).
H. microdonta. Very common (=*Polygyra*).
H. ventricosa Not uncommon (= *Helicella?* See under *Bulimus*, where it is apparently repeated).
*H. appressa. Only one locality known, near St. Georges (=*Polygyra*).
Cionella acicula. Very rare.
*Pupa fallax. Rare (=*Pupoides marginatus*).
P. pellucida. Rare (=*P. servilis*).
P. jamaicensis. Rare.
Succinea fulgens. Not common (=*S. barbadensis*).
S. bermudensis. Common (=var. of last).
S. margarita. Not common (=var. of last).
Bulimus ventrosus. Very common (=*Helicella ventricosa?*).
Helicina convexa. Common.
Truncatella subcylindrica. Not common.
*T. pulchella. Rare.

Melampus redfieldii. Common ; borders of mangrove swamps.

*Pedipes tridens. Not uncommon.

*Alexia bermudensis. Common under stones ; borders of mangrove swamps.

1881.—Bland, in Wallace's Island Life, p. 256, gives a list with the following species additional to his list of 1861. Most of them were included in Jones' list of 1876.

Hyalina discrepans.
Hyalina nelsoni.
Pupa barbadensis.
Helix appressa.
Helix pulchella.
Patula reiniana.
" hypolepta.
Stenogyra octona.

1884.—An Account of the Land and Freshwater Mollusca collected during the Voyage of the 'Challenger,' P. Z. S., Lond., p. 276. By E. A. Smith. Eight common species were obtained by the 'Challenger,' in 1873, and *Amalia gagates* is recorded for the first time.

1889.—On the Helicoid Land Mollusks of Bermuda, by H. A. Pilsbry, in Proc. Acad. Nat. Sci. Phila., 1888, pp. 285–291, pl. xvii.

Deals chiefly with *Pœcilozonites*, which is anatomically characterized. Reprinted in Heilprin's The Bermuda Islands, pp. 191–201, pl. 16.

1889.—The Bermuda Islands, by Angelo Heilprin. Land Mollusks on pp. 181–184.

In addition to the forms enumerated by Jones, Kobelt, Fischer and by Bland in Wallace, the following are given as occurring in Bermuda.

Bulimulus decollatus L. (= *Rumina*)

Melampus pusillus Gmel. (erroneous identification).

" (Tralia) cingulatus Pfr. (erroneous identification).

Truncatella caribæensis Sow.

Onchidium transatlanticum Heilpr. (= *O. floridanum*).

EXPLANATION OF PLATE LXII.

All the figures were drawn by Mr. Alpheus H. Verrill except figures 2*a*, 2*b*, 6, 7, 8, which were drawn by the author, and 16, 17 which are from Binney's Gould.

Figure 1*a*, 1*b*.—*Thysanophora vortex.* × 5½.
Figure 2*a*, 2*b*.—*Thysanophora hypolepta.* × 10.
Figure 3.—*Polygyra microdonta.* × 3.
Figure 4.—*Subulina octona.* × 2.
Figure 5.—*Opeas swiftianum.* × 2½.
Figure 6.—*Pupa servilis.* × 12.
Figure 7.—*Pupa jamaicensis.*. × 12.
Figure 8.—*Pupa rupicola.* × 12.
Figure 9, 9*a*.—*Pœcilozonites circumfirmatus.* × 2½.
Figure 10.—*Pedipes tridens.* × 15.
Figure 11.—*Plecotrema cubense.* × 15.
Figure 12.—*Truncatella bilabiata.* × 10.
Figure 13.—*Truncatella clathrus.* × 10.
Figure 14.—*Truncatella caribæensis* ; young. × 8.
Figure 14*a*.—The same ; adult. × 8.
Figure 15, 15*a*.—*Helicina convexa.* × 2½.
Figure 16.—*Pupoides marginatus.* × 6½.
Figure 17.—*Zonitoides minusculus.* × 4.

XI.—Additions to the Ichthyological Fauna of the Bermudas, from the Collections of the Yale Expedition of 1898.

By Samuel Garman.

Three species are represented by the fishes sent me for identification. One of them is a Labroid that is common along the coast of Florida and among the West Indies; its occurrence in the Bermuda waters has been noted by Goode and Bean. The second is a Gobroid of which the habitat has heretofore been undetermined. The fact that the type locality is unknown gives the more importance to the specimen in the present collection. The third species is a Brotuloid which has a close ally in one from the Florida Keys, and in another from the coasts of Lower California. Though the differences are slight, they are such as to make it necessary to describe and name the Bermudan form as a new species. The following are the species as determined. They were all taken in shallow water, by the dredge.

Platyglossus bivittatus Bloch, 1791.

D. 20; A. 15; V. 6; P. 12; Ll. 26; Ltr. 2 + 1 + 7-8.

The specimen examined has a total length of 0.064, length of head 0.0165, length from snout to dorsal 0 0165, length from snout to anal 0.0295, length from snout to caudal 0.052, length of eye 0.004, and length of snout 0.004 metres. This species was placed in *Choerojulis* by Goode and Bean and in *Iridio* by Jordan and Evermann.

Hab. Florida and the West Indies to northern South America and to the Bermudas. Bailey Bay, 4–6 fathoms.—(A. E. V.)

Gobius stigmaturus Goode and Bean, 1882.

D. 6 + 12; 13; Ll. 33; Ltr. 10.

Entire length 0.042, length of head 0.008, distance from snout to dorsal 0.012, distance from snout to anal 0.0175, length of caudal fin 0.011, and length of eye 0.003 metres.

Hab. Bermuda Islands. Off Bailey Bay, 4–6 fathoms.

This capture makes it appear very likely that the type from which the original description was secured was taken in the same locality rather than in the West Indies.

Brosmophycis Verrillii sp. nov.

Br. r. 7; D. 70; A. 50; Ll. 100; Ltr. 23.

Total length 0.045, length of head 0.011, distance from snout to dorsal 0.013, distance from snout to anal 0.02, length from snout to caudal 0.04, depth of body 0.007, length of ventral 0.01, length of eye 0.001, length of snout 0.002, length of pectoral 0.007, and length of maxillary 0.005 metres.

Body moderately robust, compressed behind the head, slender in the caudal pedicel, slightly arched from snout to caudal, greatest depth of body little more than one-sixth of the total length. Head as wide as deep, convex on the crown, arched transversely and longitudinally, depressed forward, convex on the sides, broadly rounded across the end of the snout, one-fourth of the total in length. Snout broad, blunt, twice as long as the eye. Mouth wide, anterior, jaws equal, maxillary nearly half as long as the head, expanded at the end to nearly twice the width of the eye, broadly rounded on the hind margin, upper edge concave posteriorly. Teeth in villiform bands on jaws and vomer and in narrow bands on the palatines; Vomerine band arched forward in the middle. Eye small, about one-tenth as long as the head, half as long as the snout, above the middle of the mouth, or slightly farther forward. Operculum with a straight sharp spine at its upper angle; no other spines on the head. Gill membranes hardly united below the mouth, free from the isthmus. Gill rakers short, compressed, as broad as long, rudimentary 2 + 12, similar on the different arches. Length of body cavity in its entirety nearly twice that of the head. The dorsal and the anal are of moderate depth and are free from the caudal though the base of the hindmost ray in each is very close to the bases of the caudal rays; the rays in both are shorter forward and longer in the posterior half, toward the caudal; the hinder angles extend backward of the bases of the caudal rays in an acute angle. Dorsal origin above the end of the anterior fourth of the pectoral. Anal origin below the base of the twenty-first ray of the dorsal. Caudal distinct, small, pointed. Pectorals small, pointed, in length equal to depth of body. Ventrals close together at their bases, inserted close behind the humeral symphysis, each a long slender filament. Pores distinct around the mouth, margins slightly produced, anterior pair on lower jaws larger. Lateral line indistinct. Scales of the body small, thin, cycloid, imbricated. Muscular portion of cheek covered by small scales. Anal papilla of slight prominence.

Light olivaceous puncticulate with brown, centers of scales darker; fins whitish, as also lower surface of head and belly. Each flank with three longitudinal yellow streaks, a single scale in width, separated from one another by spaces five scales in width, beginning behind the shoulders and ending forward of the caudal, lowest one longer. Each stripe bears a remote resemblance to a lateral line. At the bases of dorsal and anal there are faint indications of similar streaks. On a photograph of this specimen when fresher, there is a darker tract on the scales of the cheek, a dark blotch below the anterior portion of the dorsal, and another above the foremost rays of the anal fin.

Named in honor of its discoverer, Professor A. E. Verrill of Yale University.

Hab. Bermuda Islands. Bailey Bay, 4–6 fathoms. One specimen.

Of the four known species of *Brosmophycis*, two, *B. marginatus* and *B. ventralis*, belong to the coasts of California and Lower California, while the third was taken at Key West, Florida. As is shown below, in affinities the new species is very close to that from Florida or that from Lower California. At present the different members of the genus may be distinguished thus:

Rostral cilia present (*Brosmophycis*);

D. 92; A. 70; bright reddish brown *marginatus.*

Rostral cilia absent (*Ogilbia*);

D. 64; A. 50; Ll. 100; brownish, without markings *ventralis.*

D. 68; A. 50; Ll. 87; Ltr. 27; uniform brownish *cayorum.*

D. 70; A. 50; Ll. 100; Ltr. 23; brownish, striped and blotched *Verrillii.*

XII.—Additions to the Marine Mollusca of the Bermudas.

By A. E. Verrill and Katherine J. Bush.

The additions to the fauna recorded in this article are mostly from the collection made at the Bermudas in April and May, 1898, by the Yale scientific party under Professor Verrill.* They are all shallow-water (less than 8 fathoms) and littoral forms, no dredging having been done outside the reefs. The new species are nearly all of small size and were mostly obtained by picking over the samples of white shell-sand dredged up from the bottom in 3 to 7 fathoms in Bailey Bay, Murray Anchorage, Harrington Sound, and Castle Harbor. A large part of the bottom of these and the other bodies of water enclosed by the outer reefs is covered with this shell-sand, which varies considerably in coarseness and in the nature of the contained organisms. In general it contains only a very small amount of fragments of corals (chiefly *Millepora* and *Oculina*), some bryozoa, more or less fragments of calcareous algæ and echinoderms, and a number of rather large foraminifera of several species.† But the bulk of the material consists of the broken shells of small mollusca, especially of bivalves of many species. Usually from 80 to 90 per cent. of the bulk of the sand is of this nature in the localities dredged. By washing such sands and sifting them into various grades of fineness it is easy to find a large number of

* The other members of the party were Messrs. M. C. Cook, W. E. Porter, and C. S. Verrill, all students in the Sheffield Scientific School of Yale University. All the species here recorded, unless otherwise stated, were collected by this party.

† The following species of Foraminifera, selected from these shell-sands, have been identified by Miss K. J. Bush by comparison with the figures in Dr. Flint's report on the "Recent Foraminifera" (Report U. S. National Museum for 1897, 1899).

Biloculina bulboides d'Orbigny, *Miliolina venusta* Karrer, *Miliolina circularis* Bornemann, *Orbitolites marginalis* Lam., with the very abundant *Orbiculina adunca* Fitchtel and Moll., which was also found by the Challenger party, and *Orbulina universa* d'Orbigny.

A single specimen was also found of an interesting form of *Peneroplis* belonging to the group having narrow, compressed forms, of which *Peneroplis arietinus* Botch is the type (Challenger Report, p. 204, pl. xiii, figs. 18, 19, 22). It differs in having a more flaring or tapered form and more numerous segments than any species hitherto described.

minute species of shells, both of gastropods and bivalves. A considerable proportion of the small gastropods were living when taken, and a smaller proportion of the bivalves. The bulk of the broken and dead shells have evidently passed through the digestive organs of the abundant large holothurians (*Stichopus*), sea-urchins (*Toxopneustes*), many fishes, etc., which swallow great quantities of the organic muds and sands for the sake of the living organisms that they contain. To this cause, in part, is also due the finely comminuted calcareous mud, which is everywhere mixed with the coarser materials.

Some interesting additions to the list of bivalves were obtained by breaking up large masses of dead corals from the reefs. These are mostly true borers, but others are nestlers that find shelter in the holes made by the boring species. No doubt there are many more species to be added to the list of the Bermuda fauna whenever careful dredging shall have been made over the large areas of bottom outside the bordering reefs, in 10 to 60 fathoms of water, where the fauna is, as yet, practically unknown. It is well-known to the local fishermen that several of the large showy shells like *Strombus gigas*, *Triton variegatus*, etc., are rarely to be found except in rather deep-water on the south side of the islands. Several of the littoral shells, also, are common on the south side, but rare or absent on the north side of the islands.

The present list does not include the pteropods, the nudibranchs, nor the tectibranchs with rudimentary shells, which will be discussed in the next article.

Several lists of the marine mollusca of the Bermudas have already been published.

J. Matthew Jones, in 1859,* published one of the earliest lists, and in 1876† added considerably to the number of species. In the latter work 87 species were included, of which 55 were gastropods, 31 bivalves, with 1 cephalopod.

A. Heilprin, in 1889,‡ enumerated 171 species, of which 110 were gastropods, 57 bivalves, and 4 cephalopods.

W. H. Dall, in 1889,§ recorded 163 species, of which 105 were

* Jones, J. Matthew. The Naturalist in Bermuda. London, 1859.

† ——— The Visitor's Guide to Bermuda, pp. 137–140. Halifax, 1876.

‡ Heilprin, Angelo. The Bermuda Islands, pp. 166–181, with plates 15 and 17. 8vo. Philadelphia, 1889.

§ Dall, William Healey. Bulletin of the U. S. National Museum, No. 37. Washington, 1889.

gastropods, 57 bivalves, with 1 cephalopod. Of these, 94 species are apparently not in Heilprin's list, though some names may be synonymous. Other species have been discovered by the naturalists of the Challenger Voyage, and by several other naturalists. In the present paper about 80 species are added to the fauna, of which about 25 appear to be new species.

Thus the list of Bermuda marine mollusca now contains about 350 determined species, mostly of West Indian origin.

A considerable number of the smaller forms from the shell-sands in our collections still remain to be determined.

Many collections brought from Bermuda contain shells bought from the local dealers in curiosities or from local fishermen who sell them to visitors. In many cases such collections contain shells and corals that do not inhabit the Bermudas, such for example as *Cypræa tigris* and *Voluta musica*, with other well-known East Indian species, which the local collectors will claim as native to the waters. So, likewise, many West Indian shells are said to occur there which, at least, need confirmation by a scientific collector.* Ever since the settlement of Bermuda there has been very free communication and much commerce with the West Indies, and many shells are often brought home from the West Indies by returning sailors, soldiers, and passengers. Therefore it is important to state whether any doubtful or rare species was personally collected or purchased.

The total number of nominal species contained in the several lists, together with those now added, amounts to about 350. To this number should be added at least 8 species of nudibranchs, 3 of *Aplysia*, and one allied to *Pleurorbranchus*. (See next article, p. 545.)

Nearly all the pteropods of the tropical Atlantic are also found in the vicinity of the Bermudas, as well as several pelagic gastropods of the Sargasso sea.

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* A specimen of the common large West Indian *Melongena* was offered to me by a colored boy who declared that he had found it on the beach at Coney Island. This may possibly have been true, but this shell has never been found at the Bermudas by a reliable collector, and therefore cannot be properly included in the faunal list. (A. E. V.)

List of Additional Species.

BIVALVIA.

Family **OSTREIDÆ.**

Alectryonia limacella (Lam.).

Alectryonia limacella Chenu, Manuel Conch., ii, p. 197, f. 1005, 1862.

Several specimens adhering firmly to gorgonians were seen in the excellent collection of Miss A. Peniston.

Family **PECTINIDÆ.**

Chlamys exasperatus (Sowerby).

Pecten exasperatus Hanley, Recent Shells, p. 273, 1856.
Pecten fuscopurpureus Conrad, Journ. Acad. Nat. Sci., Philadelphia, new series, i, pp. 209, 280, pl. 29, f. 10, 1849.
Pecten exasperatus Dall, Bull. U. S. Nat. Mus., No. 37, p. 34, 1889.

The young of a form agreeing with the typical *P. fuscopurpureus* of Conrad are not uncommon. Dr. Dall considers it one of the variations which grade into the typical *exasperatus* of Sowerby.

Lyropecten nodosus (Linné).

Pecten nodosus Hanley, Recent Shells, p. 279, 1856. Chenu, Manuel Conch., ii, p. 183, f. 922, 1862. Dall, Bull. U. S. Nat. Mus., No. 37, p. 34, 1889.
Lyropecten nodosus Verrill, these Transactions, p. 63, 1897.

One broken specimen of this species was dredged in 1898. Several fine examples were seen in Miss Peniston's local collection.

Family **MYTILIDÆ.**

Modiola (Botulina) opifex Say.

Plate LVIII. Fig. 3.

Modiola opifex Say, Journ. Acad. Nat. Sci., Philadelphia, iv, p. 369, pl. xix, f. 2, May, 1825. Philippi, Conchylien, iii, p. 21, tab. ii, f. 7, 1851. Dall, Bull. U. S. Nat. Mus., No. 37, p. 38, 1889.

Not uncommon. Our specimens are young.

Modiola (Botula) cinnamomea Lam.

Modiola cinnamonea Lam., in Hanley, Recent Shells, p. 238, pl. 24, f. 24, 1856 (should be *cinnamomea*). Dall, Bull. U. S. Nat. Mus., No. 37, p. 38, 1889.

One specimen, from dead coral.

Lithophaga niger (d'Orb., 1846).

Lithodomus niger d'Orbigny, L'Ile de Cuba, p. 331, Atlas, pl. xxviii, figs. 10, 11, 1853.
Modiola Antillarum Philippi, Conchylien, iii, p. 20, tab. ii, f. 4, 1847 (*non* d'Orbigny, 1846); *L. Antillarum* d'Orbigny, 1846, same as *corrugatum* Philippi, 1846).
Lithophaga Antillarum Dall, Bull. U. S. Nat. Mus., No. 37, p. 38, 1889.

There seems to be considerable doubt as to the correct name to be applied to this very common species, which agrees perfectly with the *L. niger* of d'Orbigny. The *Antillarum* of d'Orbigny (1846) is a much larger species, of lighter color, with the striations covering the entire surface. It differs from the *Antillarum* of Philippi (1847) but agrees with *corrugatum* of Philippi (1846).

Numerous living specimens were taken from dead coral.

Family **ARCIDÆ.**

Pectunculus undatus Linné.

Pectunculus undatus Dall, Blake Report, pt. i, p. 238, 1885; Bull. U. S. Nat. Mus., No. 37, p. 42, 1889.

Only one valve was dredged. Others were seen in local collections.

Family **CARDITIDÆ.**

Cardita Dominguensis d'Orb., 1846.

Plate LXIII. Figs. 6, 7 and 8.

Cardita Dominguensis d'Orbigny, L'Ile de Cuba, ii, p. 291, Atlas, pl. xxvii, figs. 27–29, 1853. Dall, Bull. U. S. Nat. Mus., No. 37, p. 46, 1889.

A small species, very common in the shell-sand.

Family **CRASSATELLIDÆ.**

Crassatellites (Crassinella) lunulata (Conrad), var. **parva** (C. B. Adams).

Plate LXIII. Fig. 11.

Thetis parva C. B. Adams, Proceedings Boston Soc. Nat. Hist., ii, p. 9, Jan., 1845.

Crassatella Gaudalupensis d'Orbigny, L'Ile de Cuba, ii, p. 289, Atlas, pl. xxvii, figs. 24-26, 1853.

Astarte lunulata Conrad, Journ. Acad. Nat. Sci., Philadelphia, vii, p. 133, 1837; Fossils of the Medial Tertiary of the United States, p. 44, pl. 21, f. 8, 1840.

Crassatella (Eriphyla) lunulata Conrad, var. *parva* Dall, Blake Report, pt. i, p. 259, 1885; Bull. U. S. Nat. Mus., No. 37, p. 48, 1889.

Crassatellites (Crassinella) Guppy and Dall, Proc. U. S. Nat. Mus., xix, p. 326, 1896. See also, Zittel, Text-book of Palæontology, i, p. 396, 1900.

This variety differs from *lunulata* Conrad in being more elongated in form with the anterior end subtruncated, with a distinct sinuation in the concentric ribs.

Very common in the shell-sands.

Family **LEPTONIDÆ.**

Lasæa Bermudensis Bush.

Plate LXIII. Figs. 4 and 5.

Lascea rubra (*pars*) Dall, Proc. U. S. Nat. Mus., xxi, p. 895, 1899.

Lascea Bermudensis Bush, Science, x, No. 243, p. 251, 1899.

Very common between tides, especially among bunches of mussels, clinging to the byssus.

Family **LUCINIDÆ.**

Lucina nux, sp. nov.

Plate LVIII. Figs. 12 and 13.

Shell small, white, higher than long, obliquely ovate in a side-view. Umbos prominent, strongly curved forward. Surface strongly costulate and subcancellate. Posterior dorsal margin descending from the umbos in a broadly rounded curve; ventral margin distinctly produced and rounded in the middle; anterior end short, broadly rounded below, subtruncated above. Lunule small, deeply excavated.

Primary radial costæ about twelve, most of them double, those near the anterior and posterior margins less distinct; in the deep grooves between them there are usually three to five delicate costulæ, finely cancellated by the smaller lines of growth. Rather strong, elevated liræ cover the entire surface, crossing both the costæ and grooves; on the former some of them rise up into scale-like prominences and on the posterior ones often become subspinulose. In the right valve there are two very unequal cardinal teeth, the central one prominent and slightly bilobed; the anterior much smaller, prominent, with a little pit between. The lateral teeth are well-developed, the anterior one much the longer. The ligament is strong, with a deep groove.

Length of the single valve, 7^{mm}; height, 8^{mm}; thickness, 3^{mm}.

Lucina reticulata Poli (*non* Lam.).

Lucina pecten Philippi, Moll. Sicily, i, p. 31, tab. iii, f. 14, 1836 (*non* Lamarck).
Lucina reticulata Philippi, Conchylien, iii, p. 104, tab. ii, f. 6, 1850.

The comparatively few specimens from Bermuda agree with Philippi's figure, but it is doubtful if they are but an elongated form of *L. pecten* Lam., being less orbicular with finer sculpture than that species, and being intermediate between *pecten*, which is rounder with coarser sculpture, and *pectinata* Ad. (*obliqua* Reeve), which has more prominent beaks and much finer sculpture.

Family **CARDIIDÆ.**

Cardium (Papyridea) Petitianum d'Orb., 1846.

Cardium Petitianum d'Orbigny, L'Ile de Cuba, ii, p. 309, Atlas, pl. xxvii, figs. 50–52, 1853. Dall, Bull. U. S. Nat. Mus., No, 37, p. 54, 1889.

Two separate immature valves were dredged.

Family **PETRICOLIDÆ.**

Petricola (Naranaio) lapicida (Gmelin).

Plate LXIII. Figs. 14 and 15.

Petricola lapicida Hanley, Recent Shells, p. 53, 1843. Dall, Bull. U. S. Nat. Mus., No. 37, p. 58, 1889.

Examples of this rare form, taken from borings in dead corals, forwarded to Dr. Dall, were identified as this species.

Coralliophaga coralliophaga (Gmel.).

PLATE LXIII. FIGS. 9 and 10.

Cypricardia coralliophaga Hanley, Recent Shells, p. 159, 1843.
? Cypricardia Hornbeckiana d'Orb., L'Ile de Cuba, ii, p. 266, Atlas, pl. xxvi, figs. 33–34, 1853.
Coralliophaga coralliophaga H. and A. Adams, Genera, ii, p. 439, pl. 109, figs. 6, 6*a*, 1858.

This very common species, identified by Dr. Dall, varies greatly, not only in form, but also in the strength and character of the hinge-teeth.

Family **TELLINIDÆ.**

Tellina Candeana d'Orb., 1846.

PLATE LXIII. FIGS. 1 and 2.

Tellina Candeana d'Orbigny, L'Ile de Cuba, ii, p. 251, Atlas, pl. xxv, figs. 50–52, 1853.

A single valve agrees with d'Orbigny's figures.

Tellina iris Say, variety **Caribæa** d'Orb., 1846.

Tellina Caribæa d'Orbigny, L'Ile de Cuba, ii, p. 251, Atlas, pl. xxv, figs. 47–49, 1853.
Tellina iris Say, Journ. Acad. Nat. Sci., Philadelphia, ii, p. 302, 1822. Tryon, Amer. Mar. Conch., p. 149, pl. 26, f. 354, 1873. Dall, Bull. U. S. Nat. Mus., No. 37, p. 60, 1889. (*? non* Philippi, Conchylien, ii, p. 25, tab. iii, f. 5, 1845.)

One worn valve which Dr. Dall thought might be a worn *iris* Say, when compared with specimens of that species from Cape Hatteras, was found to be much larger, of quite different shape, with more numerous, oblique lines. Although Dr. Dall considers *Caribæa* but one of the forms of *iris*, it is such an extreme one, that it seems desirable to retain the name, at least, as a variety.

Tellina simplex d'Orb., 1846.

Tellina simplex d'Orbigny, L'Ile de Cuba, ii, p. 255, Atlas, pl. xxvi, figs. 15–17, 1853.

Common in the dredged shell-sand.

Tellina mera Say.

Tellina mera Say, Amer. Conch., pt. vii, p. 228, pl. lxiv, f. 2.
Tellina mera Binney's Say's Conch. U. S., p. 228, pl. 64, f. 2, 1858.
Strigilla mera Tryon, Amer. Marine Conch., p. 151, f. 366, 1873.
Tellina mera Dall, Bull. U. S. Nat. Mus., No. 37, p. 60, 1889.

Shells from Bermuda have a shorter and more inflated form than Say's figure represents, but they are considered this species by Dr. Dall. They look like worn examples of the following species.

Found in the shell-sand.

Tellina (Angulus) (sp. nov.).

Shells found with *mera* Say were identified as this new species by Dr. Dall. It is closely related to that species, but has a more elongated form, with less crowded concentric sculpture.

The description is to be included in a report on the Tellinidæ by Dr. Dall, soon to appear in one of the government publications.

Macoma (Psammacoma) tenta (Say), variety *Souleyetiana* Recl.

Tellina tenta Say, Amer. Conch., pt. vii, p. 228, pl. lxv, f. 3, 18—. Binney's Say's Conch. U. S., p. 228, pl. lxv, f. 3, 1858.
Tellina Souleyetiana Recluz, Journ. de Conch., iii, p. 253, pl. x, figs. 5–5′, 1852.
Tellina tenta Tyron, Amer. Marine Conch., p. 149, figs. 350–351, 1873.
Macoma (Psammacoma) tenta Say, var. *Souleyetiana* Dall, Bull. U. S. Nat. Mus., No. 37, p. 60, 1889.

We are indebted to Dr. Dall for the identification of this form, which is abundant in the dredged shell-sand.

Family **SEMELIDÆ.**

Semele orbiculata (Say), var. **radiata** (Say).

Amphidesma orbiculata Say, Journ. Acad. Nat. Sci., Philadelphia, ii, p. 317, 1822.
Amphidesma radiata Say, op. cit, v, p. 220, 1826.
Amphidesma radiatum Say, in Hanley, Recent Shells, p. 342, pl. 12, f. 8 (as *A. austrate*) and *A. subtruncatum* Sowerby, 1856.
Semele orbiculata Tryon, Amer. Mar. Conch., p. 154, pl. 27, f. 382, 1873.
Semele radiata Tryon, op. cit., f. 383.
Semele reticula Dall, Bull. U. S. Nat. Mus., No. 37, p. 62, 1889.

This has formerly been recorded from Bermuda under the name *reticulata*.

Common in shallow-water.

Semele bellastriata (Conrad).

Amphidesma bellastriata Conrad, Journ. Acad. Nat. Sci., Philadelphia, vii, p. 239, pl. xx, f. 4, 1837.
Amphidesma cancellata d'Orbigny, L'Ile de Cuba, ii, p. 241, Atlas, pl. xxv, figs. 42–44, 1853.
Semele nexilis Gould, Proc. Boston Soc. Nat. Hist., viii, p. 281, 1862.
Semele cancellata Dall, Bull. U. S. Nat. Mus., No. 37, p. 62, 1889.

Formerly recorded from Bermuda under the name *cancellata*.

Not uncommon.

Family **GASTROCHÆNIDÆ.**

Gastrochæna (Spengleria) rostrata Spengler.

*Gastrochæna mytiloides** Lamarck, in Hanley, Recent Shells, p. 10, pl. 9, fig. 37, 1842.

Gastrochæna Chemnitziana d'Orbigny, L'Ile de Cuba, ii, p. 229, pl. xxv, figs. 29–30, 1853.

Rocellaria (Spengleria) rostrata Spengler, in Tryon, Structural and Systematic Conchology, iii, p. 120, pl. 104, f. 47, 1884.

Gastrochæna (Spengleria) rostrata Dall, Bull. U. S. Nat. Mus., No. 37, p. 72, 1889.

Common in borings in both dead and living coral.

Family **TEREDINIDÆ.**

Teredo Thomsoni Tryon.

Teredo Thomsoni Tryon, Proc. Acad. Nat. Sci., Philadelphia, p. 280, pl. 3, figs. 3–5, 1863. Gould, Invert. of Mass., p. 31, f. 358, 1870. Dall, Bull. U. S. Nat. Mus., No. 37, p, 74, 1889.

This large species was found in great abundance in a large log cast ashore at Bailey Bay.

GASTROPODA.

OPISTHOBRANCHIATA; TECTIBRANCHIATA.

Family **ACTÆONIDÆ.**

Actæon punctostriatus (C. B. Adams).

PLATE LXV. FIGS. 15 and 18.

Tonatella punctostriatus C. B. Adams, Boston Journ. Nat. Hist., ii, p. 323, pl. iii, f. 9, 1840.

Actæon punctostriatus Bush, these Trans., vi, p. 467, pl. xlv, f. 17, 1885. Dall, Blake Report, pt. ii, p. 40, 1889; Bull. U. S. Nat. Mus., No. 37, p. 84, pl. xli, f. 17, pl. lii, f. 22, 1889.

The half dozen specimens from Bermuda agree in the size of the nucleus with examples from New England, but among those from off Cape Hatteras, N. C., there is great variation in this character, as shown in the figure.

* d'Orbigny calls attention to the close resemblance of his shell to the *mytiloides* of Lamarck.

Family **TORNATINIDÆ.**

Tornatina recta (d'Orb.).

PLATE LXIV. FIG. 2.

Bulla recta d'Orbigny, L'Ile de Cuba, i, p. 131, Atlas, pl. iv bis, figs. 17–20, 1853.
Tornatina recta Dall, Bull. U. S. Nat. Mus., No. 37, p. 84, 1889. Pilsbry, Manual Conch., xv, p. 184, pl. 22, figs. 13–15, 1893.

Rare in the dredged shell-sand.

Tornatina decurrens, sp. nov.

PLATE LXIV. FIG. 1.

Shell white, minute, oblong-elliptical, with a somewhat turreted spire, consisting of about two whorls, besides the relatively large and prominent, vertically upturned nucleus, which consists of nearly three whorls. Suture impressed and slightly canaliculate, that of the body-whorl very oblique. Aperture long, much narrowed posteriorly, somewhat expanded anteriorly, with a distinct, very oblique fold on the columellar margin. Surface smooth and polished.

Length from 2.5 to 3^{mm}; breadth, 1.12 to 1.5^{mm}.

This rare species is readily recognized by its very oblique suture.

Found in the dredged shell-sand.

Family **SCAPHANDRIDÆ.**

Cylichna Auberi (d'Orb.).

PLATE LXIV. FIG. 3.

Bulla Auberi d'Orbigny, L'Ile de Cuba, i, p. 127, Atlas, pl. iv bis, figs. 5–8, 1853.
Cylichna Auberi Dall, Blake Report, pt. ii, p. 55, 1889.

Rare ; found in the dredged shell-sand.

Family **BULLIDÆ.**

Bulla Bermudæ, sp. nov.

PLATE LXIV. FIG. 4.

Shell white, minute, oblong-ovate, broadest anterior to the middle. Body-whorl flattened and sometimes slightly constricted just above the middle. Summit subtruncate, with the angle obtusely rounded and with the posterior margin of the lip rising slightly in an obtuse

curve ; apical region with a shallow, but distinct depression. Surface nearly smooth, but usually showing microscopic revolving lines, especially on the posterior half ; in the young covering the entire surface. Aperture longer than the body-whorl, narrowed in the middle but expanded at each end, the anterior margin considerably produced and somewhat flaring ; a minute perforate umbilicus in some specimens, columellar margin thickened and nearly straight.

Length of the largest specimen, 3^{mm} ; breadth, 1.6^{mm}.

Rare, in the dredged shell-sand.

Haminea Antillarum (d'Orb)., var. **Gaudalupensis** Sowerby.

Plate LXIV. Fig. 6.

Bulla Antillarum d'Orbigny, L'Ile de Cuba, i, p. 124, Atlas, pl. iv, figs. 9–12, 1853.

Haminea Antillarum Mörch, Syn. Moll. Mar., p. 175, 1875. Dall, Bull. U. S. Nat. Mus., No. 37, p. 84, 1889. Pilsbry, Manual Conch., xv, p. 358, pl. 41, figs. 30–36, 1893, with variety *Gaudalupensis* Sowerby.

Rare in dredged shell-sand.

Family **SIPHONARIDÆ.**

Siphonaria henica, sp. nov.

Plate LXV. Fig. 8. Plate LXVI. Fig. 8.

Shell with a broad, elliptical aperture; a moderately elevated strongly recurved apex, situated near the posterior margin ; and with the surface covered with regular, rather fine, radial costulæ and strongly marked, undulating lines of growth which interrupt the costulæ, giving an irregularly cancellated appearance ; the costulæ are also crossed by fine, intermediate lines of growth. The apical portion consists of a small spiral nucleus of about 1½ whorls turned a little to the left side, and of an expanded, smooth, hood-like, nepionic stage. The costulæ commencing at the edge of the latter are at first fine and regular, becoming coarser as they approach the margin. Interior white and glossy, with the muscular scars well-marked, and with a distinct, pulmonary sinus, which forms a distinct emargination at the margin, which is sometimes entire and sometimes crenulated by the costulæ.

Color of the single live specimen, white tinged with yellow.

Length of aperture, 7.8^{mm} ; breadth, 7.1^{mm} ; height, 3^{mm}. Bailey Bay, shore.

PROSOBRANCHIATA.

RHIPHIDOGLOSSA.

Family **STOMATIIDÆ.**

Synaptocochlea Pilsbry, 1890. Type, *S. Montrouzier* Pilsbry.

Synaptocochlea Pilsbry, Manual Conch., xii, p. 6, 1890.

Synaptocochlea picta (d'Orb.) Pilsbry.

Plate LXIV. Figs. 5 and 12.

Stomatia picta d'Orbigny, L'Ile de Cuba, ii, p. 184, Atlas, pl. xxiv, figs. 19–21, 1853. Heilprin, op. cit., p. 175, 1889.

Stomatella picta Dall, Bull. U. S. Nat. Mus., No. 37, p. 168, 1889. Pilsbry, Manual Conch., xii, p. 29, pl. 54, figs. 19–20, pl. 21, figs. 22–25, 1890. (*Non Stomatella picta* Montrouzier, 1862 = *S. Montrouzieri* Pilsbry, 1890.)

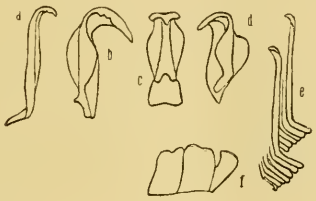

Figure 1. Radular teeth of *S. picta*. Camera-lucida drawing, greatly enlarged.

In the radula, the strongly hooked and finely serrate teeth are arranged in many rows, in each of which there are from 40 to 50 ; 15–20 slender marginals with much bent bases, as *a* and *e* ; 5 or 6 lateral, as *d*, the outer one (*b*) larger than the others; and one broad median (*c*). In some of the posterior rows, broad marginals are found, as *f*. The operculum is circular, of few whorls, with central nucleus, very thin, of a delicate horn-color.

Common in the shell-sand. Recorded also by Heilprin.

Family **SCISSURELLIDÆ.**

Scissurella costata d'Orb.

Scissurella costata Pilsbry, Manual Conch., xii, p. 50, pl. 50, f. 1, 1890.

One specimen, in shell-sand.

Schisomope cingulata (O. G. Costa).

Schisomope cingulata Pilsbry, Manual Conch., xii, p. 61, pl. 57, figs. 1–7, 1890.

One young specimen with three of another, apparently undescribed species.

Family **FISSURELLIDÆ.**

Emarginula, sp.

Two young specimens of an apparently undescribed species of *Emarginula* were found.

The larger is oblong or subelliptical in outline, with an elevated, strongly incurved apex and a narrow, deep, marginal notch. The surface, near the margin, is covered with well-marked costæ crossed by fine concentric lines of growth.

It differs from the young of *E. pumila* Ad. and its variety *pileum* (Heilprin), of which a number of living specimens were taken.

GYMNOGLOSSA.

Family **EULIMIDÆ.**

Eulima hypsela, sp. nov.

PLATE LXIV. FIG. 9.

Shell rather slender, very elongated, with sixteen whorls in the adult, besides the very minute apical whorl. Whorls very flat, so that the outlines of the spire are rectilinear. Suture distinct not impressed, somewhat oblique (more so than in *E. amblytera*). Body-whorl evenly rounded, somewhat produced and narrowed in front. Aperture long-ovate, acute posteriorly, obtusely rounded and somewhat flaring anteriorly and at the columellar margin, its edge strongly sinuous in a profile view.

Color bluish white, slightly tinged with brown on the lower whorls and with a strong brown tint showing through by transparency on most of the upper whorls; sometimes pure white; surface smooth and brilliantly polished.

Length of the largest example (upper whorls wanting), 8^{mm}; breadth, 2.5^{mm}.

A number of examples were found in the shell-sand.

Eulima amblytera, sp. nov.

PLATE LXIV. FIG. 8.

Shell white, elongated, subfusiform with a long, evenly tapered, nearly straight spire and an evenly rounded, produced body-whorl. Sutures distinct but scarcely impressed, not very oblique. Outlines of the spire nearly straight, owing to the flatness of the whorls. Whorls nine in the largest specimen, besides the relatively large mammiform, apical whorl. Aperture long-ovate, obtusely rounded,

slightly flaring in front, acute posteriorly; anterior part of the outer-lip and columellar margin sometimes thickened in the adult. Surface smooth and brilliantly polished.

Length, 5.5^{mm}; breadth, about 0.6^{mm}.

The apical whorl is more obtuse and larger than in most of the Bermudian species.

A few specimens were found in the shell-sand.

Eulima engonia, sp. nov.

PLATE LXIV. FIG. 7.

Shell moderately elongated, rapidly tapered to the very acute apex. Whorls twelve or more when full grown, besides the very minute, rounded, apical whorl. Whorls of the spire completely flattened, so that the outlines are rectilinear; suture distinct, but not impressed, little oblique. Body-whorl distinctly but obtusely angulated at the periphery, relatively short and broad, not produced. Aperture broad-ovate or subrhombic, due to the angulation in the middle of the outer lip and a slight angle at the junction of the columella with the inner lip; anterior margin rounded and slightly flaring. Outer lip strongly sinuous in a profile view, with a distinct incurved posterior notch. Color bluish white, sometimes tinged with brownish yellow.

Length, 4.5^{mm}; breadth, about 1.5^{mm}. There are fragments of larger examples.

Several specimens in the shell-sand.

This species is easily distinguished from the others herein included by the broader, angulated body-whorl, the wider aperture, and the minute nucleus, which is similar to that of *E. hypsela.*

Eulima compsa, sp. nov.

PLATE LXIV. FIG. 16.

Shell minute, elongated, subfusiform, composed of about eight whorls, besides the rather small, prominent, rounded apical whorl. Outlines of the spire rectilinear. Whorls flattened; suture rather indistinct, slightly oblique. Body-whorl elongated, strongly produced anteriorly. Aperture regularly ovate, evenly rounded and flaring in front; outer lip regularly curved, acute, somewhat sinuous in profile view.

Color white; surface polished.

Length of the single specimen, about 3.5^{mm}; breadth, about 1.5^{mm}.

Found in the shell-sand.

Eulima atypha, sp. nov.

PLATE LXIV. FIG. 10.

Shell minute, elongated, subfusiform with the spire somewhat crooked. Whorls seven or eight, besides the somewhat upturned, rather prominent, mammiform apical whorl. Whorls flattened or a little convex. Sutures rather distinct, slightly oblique. Body-whorl long, regularly curved, produced anteriorly. Aperture small, regularly ovate; collumellar margin thickened and somewhat produced and reflected anteriorly. Outer lip regularly curved.

Color bluish white, the surface brilliantly polished.

Length, about 2.2^{mm}; breadth, about 0.8^{mm}.

This species is distinguished by the peculiar apical whorl, by the produced body-whorl, and by the small ovate aperture.

Two specimens from the shell-sand.

Family **PYRAMIDELLIDÆ.**

Pyramidella dolabrata Linné.

Pyramidella dolabrata Tryon, Manual Conch., viii, p. 300, pl. 72, figs. 71–74, 1886. Dall, Bull. U. S. Nat. Mus., No. 37, p. 128, 1889.

Specimens said to have been collected in Bermuda were seen in several local collections.

Turbonilla Heilprini Bush.

PLATE LXV. FIG. 12.

Turbonilla Heilprini Bush, Proc. Acad. Nat. Sci., Philadelphia, pp. 167, 172, pl. viii, f. 13, 1899.

The only specimen seen was obtained by Mr. Heilprin's party, in 1889.

Turbonilla valida, sp. nov.

PLATE LXIV. FIG. 20.

Shell white, slender, much elongated, consisting of ten convex, costulate whorls with deep sutures, besides the relatively large, upturned, apical whorl. The whorls of the spire are evenly and strongly convex, crossed by twelve to fourteen strong, prominent, obtuse, longitudinal ribs, separated by deep, concave interspaces of about the same breadth and without any spiral sculpture. The suture is decidedly oblique and deeply impressed. Body-whorl is rather large, not much produced anteriorly, with a smooth base.

The large, prominent nucleus, consisting of about two whorls, is strongly upturned so as to lie in a plane transverse to the axis of the spire. The aperture is regularly ovate with a somewhat thickened margin, flaring anteriorly.

Length of the only specimen, 5.5^{mm}; breadth, 1.35^{mm}.

This species is distinguished from other Bermudian *Turbonillæ* by its deep suture, comparatively few longitudinal ribs, and the large nucleus.

Found in the dredged shell-sand.

Turbonilla leuca Bush.

PLATE LXIV. FIG. 18.

Turbonilla leuca Bush, Proc. Acad. Nat. Sci., Philadelphia, pp. 167, 172, 1899.

Rare; found in the shell-sand.

Turbonilla Penistoni Bush.

PLATE LXV. FIG. 13.

Turbonilla pulchella Heilprin, The Bermudas, p. 173, 1889 (*non* d'Orbigny).
Turbonilla Penistoni Bush, Proc. Acad. Nat. Sci., Philadelphia, pp. 165, 172, pl. viii, f. 14, 1899.

Comparatively rare in the shell-sand.

Turbonilla Swiftii Bush.

PLATE LXIV. FIGS. 21 and 21*a*.

Turbonilla Swiftii Bush, Proc. Acad. Nat. Sci., Philadelphia, pp. 166, 173, 1899.

Two young agree more closely with this than any other described species.

Found in the shell-sand.

Pyrgostelis Monte., 1884. Type *P. rufa* (Philippi).

Pyrgostelis Monterosato, Nom., Genera and Species, Conch., Med., p. 89, 1884. Tryon, Manual Conch., viii, p. 318, 1886.

Longitudinal ribs not extending below the periphery of the body-whorl; interspaces and base cut by equal, or nearly equal, incised spiral lines. Color white, fulvous, or banded. Columella with a more or less prominent reentering fold. In its most extended sense this genus should include all the species, hitherto referred to *Turbonilla*,

having spiral sculpture. In a restricted sense it includes only those having spiral sculpture similar in character to that of *rufa* of Philippi.

Pyrgostelis puncta (C. B. Adams).

PLATE LXIV. FIGS. 19 and 19*a*.

Chemnitzia puncta C. B. Adams, Cont. to Conch., No. 5, p. 72, 1850. Mörch, Syn. Moll. Mar., p. 162, 1875.

Turbonilla puncta Tryon, Manual Conch., viii, p. 331 (not pl. 76, fig. 22), 1886. (?) Dall, Bull. U. S. Nat. Mus., No. 37, p. 128, 1889. Bush, Proc. Acad. Nat. Sci., Philadelphia, pp. 162, 174, 1899.

Common in the shell-sand.

Pyrgostelis fasciata (d'Orb.)?

Turbonilla fasciata Bush, Proc. Acad. Nat. Sci., Philadelphia, pp. 155, 175, 1899; (not *Chemnitzia fasciata* Req., 1848 = *Pyrgostelis fulvocincta* Thompson, nor *Turbonilla fasciata* Forbes, 1843=*Eulimella*).

Found in the shell-sand.

Subgenus **Mumiola** A. Adams, 1864. Type, *M. spirata* A. Adams.

Mumiola A. Adams, Journ. Linnæan Soc., vii, p. 5, 1864. Tryon, 1886, in part (not *Mumiola* Monterosato, 1884).*

"Test thin, elongate or ovate; whorls convex, cancellated or granulose. Aperture ovate; margin of the lip regularly arched."

"An ovate, cancellate group which is named *Mumiola*."

First species—*Monoptygma spirata* A. Adams, 1851 (not *Chemnitzia spirata* Kurtz and Stimpson, 1851=*Ondina*, nor *Parthenia spirata* A. Adams, 1860=*Pyrgostelis*)—taken for type.

"Surface regularly and beautifully decussated with raised lines."

Shell light brown or yellowish with ribs extending over the base, with the interstices crossed by raised spirals.

Pyrgostelis (Mumiola) asperula Bush.

PLATE LXV. FIG. 23.

Turbonilla asperula Bush, Proc. Acad. Nat. Sci., Philadelphia, pp. 151, 176, 1899.

Not uncommon in the shell-sand.

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* *Mumiola* Monterosato, 1884=*Odostomiella* Bucq., Dautz. Dollf., 1883. Type *O. doliolum* Phil. Figured in Report of Expeditions by Prince Monaco.

Subgenus **Mormula** A. Adams, 1864. Type, *M. rissoina* A. Adams.

Mormula A. Adams, Journ. Linnæan Soc., vii, p. 1, 1864. Tryon, 1886, in part.

"Test subulate-turrited, rissoid, solid, thick, longitudinally plicate. Aperture large; inner lip spirally twisted; outer lip somewhat thickened within with a sharp edge.

"A plicate form with spiral axis which is named *Mormula*." First species—*M. rissoina* A. Adams—taken for type.

Brown-banded of seven (7) flattened whorls, with thick, undulating, longitudinal plications, with the interstices very much lirate.

"Very much resembling a *Rissoina* with the inner lip spirally twisted and with the nucleus sinistral."

Pyrgostelis (Mormula) pupoides d'Orb., and variety **ischna** Bush.

Plate LXV. Figs. 21 and 22.

Chemnitzia pupoides d'Orbigny, L'Ile de Cuba, i, p. 224, Atlas, pl. xvi, figs. 32–36, 1853.

Chemnitzia (Mumiola) pupoides Mörch, Syn. Moll. Mar., p. 164, 1875.

Turbonilla pupoides Tryon, Manual Conch., viii, p. 332, pl. 76, f. 26, 1886.

? *Odostomia phrikalea* Watson, Challenger Report, xv, p. 493, pl. xxxii, f. 7, 1885.

Turbonilla pupoides Bush, Proc. Acad. Nat. Sci., Philadelphia, pp. 152, 176, pl. viii, f. 5, 1899.

Very common in the shell-sand.

Odostomia Jonesii, sp. nov.

Plate LXIV. Fig. 13.

Shell white, smooth, polished, ovate, composed of five or six whorls, besides the nucleus. Suture little impressed and sometimes slightly canaliculate. Whorls slightly but evenly convex, the last slightly diminished in diameter in some instances, giving the shell a slightly fusiform appearance. Nucleus with a very small, upturned, apical whorl. Aperture rather broad-ovate; outer lip regularly rounded; columellar margin very oblique and sinuous, with a well-marked oblique plication. Some specimens have a slight umbilical chink, others have none.

Length, 3.5^{mm}; breadth, about 0.2^{mm}.

This species appears to be more nearly related to *O. nitens* Jeffreys than to any other described *Odostomia*.

It is larger, stouter and less fusiform with a broader and relatively shorter aperture, with the columellar fold stronger and situated more anteriorly.

Common in the dredged shell-sand.

Odostomia ovuloides C. B. Adams, 1850.

PLATE LXIV. FIG. 14.

Odostomia ovuloides C. B. Adams, Contr. to Conch., No. 7, p. 109, 1850.
Odostomia lævigata d'Orbigny, L'Ile de Cuba, i, p. 227, Atlas, pl. xvii, figs. 7-9, 1853. Mörch, Syn. Moll. Mar., p. 166, 1875. Tryon, Manual Conch., viii, p. 357, pl. 78, f. 44, 1886.

Three examples from the shell-sand are identified as this species.

Odostomia lubrica, sp. nov.

PLATE LXIV. FIG. 15.

Shell white, smooth, polished, rather stout-ovate, rapidly tapered, acute, composed of five whorls besides the small, abruptly upturned nucleus. Suture deeply impressed, the whorls being slightly angulated just below it. Whorls evenly convex; body-whorl relatively large, swollen, with the base wellrounded, but not produced. Aperture broadly ovate ; outer lip broadly and evenly rounded, not angulated anteriorly. Columellar margin sinuous, with a distinct plication within the aperture. Umbilical chink small, but distinct.

Length of the single perfect specimen, 2.2^{mm} ; breadth, about 1.2^{mm}.

Several other examples, imperfect and worn, but having a somewhat angular body-whorl, are doubtfully referred to this species.

From the shell-sand.

Subgenus **Cyclodostomia** Sacco, 1892. Type, *C. Mutinensis* Sacco.

Cyclodostomia Sacco, Mem. Reale Acc. Sci. Turino, xlii, 2d series, p. 628, 1892.

"Shell small, more or less conic. Whorls angular sometimes and near the suture above with a small but distinct cingulum. Columella uniplicate."

First species—*C. Mutinensis* Sacco, (Tab. i, f. 102) 1892—taken for type.

The sides of each whorl concave with a cingulum just below each suture.

Odostomia (Cyclodostomia) didyma, sp. nov.

Plate LXV. Fig. 14.

Shell minute, white, subovate, consisting of five whorls besides the minute, slightly prominent, upturned, apical whorl. The whorls of the spire are strongly flattened and somewhat concave in the middle, with a somewhat raised, thick, rounded cingulum just above, and one just below the suture, which is deeply impressed and somewhat canaliculate. On the body-whorl there is a deep groove just below the peripheral cingulum, bordered anteriorly by another similar cingulum. Base but little produced, with a small spiral rib in the umbilical region. Aperture small, broad-ovate, slightly flaring anteriorly.

Length of the only specimen, 1.3^{mm}; breadth, about 0.7^{mm}.

From the shell-sand.

Subgenus **Evalea** A. Adams, 1860. Type, *E. elegans* A. Adams.

Evalea A. Adams, Ann. Mag. Nat. Hist., vi, p. 22, 1860.

"Test having the form of an elevated cone, somewhat turrited, high spire with the whorls (5) transversely sulcate or striate. Aperture oval; outer lip produced with a transverse columellar fold."

First species—*Odostomia elegans* A. Adams, 1860 (*non* Monterosato, 1869)—taken for type.

Transversely grooved or sulcate species of *Odostomia.*

Odostomia (Evalea) Somersi, sp. nov.

Plate LXV. Fig. 7.

Shell small, thick, ovate with four whorls besides the small, upturned nucleus. Suture canaliculate. Whorls slightly convex, with three narrow, incised grooves, producing three broad, strong, rounded cingula. Base of the body-whorl smooth. Aperture ovate, acute posteriorly, slightly produced at the anterior angle, and with a distinct columellar plication deep within the aperture.

Color white, sometimes in fresh specimens tinged with flesh-color.

Length, 2.5^{mm}; breadth, about 1.28^{mm}.

Common in the shell-sand.

Subgenus **Cingulina** A. Adams, 1860. Type, *C. circinata* A. Adams.

Cingulina A. Adams, Ann. Mag. Nat. Hist., vi, 3d series, p. 414, 1860.
Polyspirella Carpenter, Proc. Boston Soc. Nat. Hist., vii, p. 407, 1861 (not defined). Type, and only species, *Chemnitzia trachealis* Gould, 1861.
(Not *Miralda* A. Adams, 1864, nor *Cingulina* Monterosato, 1884=*Rissoa*.)

"Test having a subulate, turrited form with the numerous whorls ornamented with elevated, spiral cingula with sculptured interstices. Aperture oblong, anteriorly entire; inner lip straight, simple; outer lip sharp and arched."

Only species and type, *C. circinata* A. Adams.

Longitudinally striate and spirally cingulate species of *Odostomia*.

Odostomia (Cingulina) Babylonia (C. B. Adams) Bush.

Plate LXV. Fig. 11.

Chemnitzia Babylonia C. B. Adams, Proc. Boston Soc. Nat. Hist., ii, p. 6, 1845.
Chemnitzia (Miralda) Babylonia Mörch, Syn. Moll. Mar., p. 165, 1875, (a *Cingulina* A. Adams).
Odostomia (Miralda) Babylonica Tryon, Manual Conch., viii, p. 358, 1886.
Odostomia (Cingulina) Babylonica Bush, Proc. Acad. Nat. Sci., Philadelphia, p. 176, 1899.

On the three specimens from Bermuda the deep spaces between the conspicuous spiral ribs are crossed by numerous microscopic, raised longitudinal lines, more nearly perpendicular than indicated in the figure. This ornamentation seems to have been overlooked by Profs. Adams and Mörch.

From the shell-sand.

Subgenus **Miralda** A. Adams, 1864. Type, *M. diadema* A. Ad.

Miralda A. Adams, Journ. Linnean Soc., vii, p. 3, 1864. Monterosato, 1884, in part. Tryon, 1886, in part.
Parthenia Carpenter, Mazatlan Moll., p. 415, (Section B, in part), 1855–7.

"Test solid, ovate or elongate; whorls plane, posteriorly plicate, anteriorly transversely lirate. Aperture with the lip posteriorly subangulate with crenate margin."

"A little group, solid, half costate and half lirate, which I designate *Miralda*."

First species—*Parthenia diadema* A. Adams, 1860—taken for the type.

Species of *Odostomia* having the whorls ornamented with more or less developed granules above and below, and on the base with distinct, sometimes conspicuous, spiral cingula.

Odostomia (Miralda) seminuda (C. B. Adams), 1839, var. **gemmulosa** C. B. Adams, 1850.

Jaminia seminuda C. B. Adams, Boston Journ. Nat. Hist., ii, p. 280, pl. iv, 13, 1839.
Odostomia seminuda Gould, Invert. Mass., ed. ii., p. 329, fig. 599. Tryon, Manual viii, p. 357, pl. 78, f. 35, 1886. Dall, Bull. U. S. Nat. Mus., No. 37, p. 130, pl. lii, f. 10, 1889.
Odostomia gemmulosa C. B. Adams, Cont. to Conch., No. 7, p. 109, 1850.
Dunkeria gemmulosa Mörch, Syn. Moll. Mar., p. 168, 1875.

One example of this slender, elongated variety was found in the shell-sand.

PTENOGLOSSA.

Family **SCALIDÆ.**

Scala uncinaticosta (d'Orb.).

PLATE LXIV. FIGS. 17 and 17*a*.

Scalaria uncinati-costa d'Orbigny, L'Ile de Cuba, ii, p. 19, Atlas, pl. xi, figs. 25–27, 1853. Tryon, Manual Conch., ix, p. 77, pl. 16, f. 95, 1887.
Scala uncinati-costa Mörch, Syn. Moll. Mar., p. 150, 1875. Dall, Blake Report, pt. ii, p. 318, 1889.

Our specimen, although much larger than the measurements given by d'Orbigny, agrees so closely in all other characters, that there can be little doubt of its being identical. The similar species (*S. turricula* Sow.) has not the sutural spines characteristic of this species. It bears some resemblance to *S. vittata* Jeffreys and *S. Algeriana* Wienkauff, from the Mediterranean.

From dredged shell-sand.

Scala echinaticosta (d'Orb.).

Scalaria echinaticosta d'Orbigny, L'Ile de Cuba, ii, p. 18, Atlas, pl. xi, figs. 4–6, 1853. Tryon, Manual Conch., ix, p. 64, pl. 13, f. 98, 1887.
Scala echinaticosta Mörch, Syn. Moll. Mar., p. 145, 1875.

Rare, found in the shell-sand.

Scala Blandii Mörch (?).

Scala echinaticosta d'Orbigny, var. (?) *Blandii* Mörch, Syn. Moll. Mar., p. 145, 1875. Tryon, Manual Conch., ix, 64, 1853, as a var. of *occidentalis* Nyst.
Scala Blandii Dall, Bull. U. S. Nat. Mus., No. 37, p. 124, 1889.

Of the half dozen examples, the largest, having five whorls below the nucleus, measures about 8.5^{mm} in length, but otherwise agrees

with Mörch's description. A larger fragment has the whorls entirely disunited. It closely resembles the figures of the very much larger species, *S. hyalina* Sowerby.

Scala electa, sp. nov.

PLATE LXIV. FIG. 11.

Shell white, small, stout, regularly conical, consisting of six regularly rounded whorls which are only slightly in contact, so that the suture is very deeply impressed. The body-whorl is crossed by about twelve, rather prominent, slightly thickened, nearly even ribs which are often slightly recurved, but not oblique ; the interstices, which are much wider, are concave and smooth. The ribs converge to, and reach deeply within the umbilicus, which is deep and rather narrow and somewhat obscured by the reflexed inner margin of the aperture. Nucleus small, regular, nearly smooth. Aperture round with a rather strongly thickened margin.

Length of the largest specimen, 8^{mm} ; breadth, 4.5^{mm}.

Several specimens were found in the dredged shell-sand.

TÆNIOGLOSSA.

Family **CERITHIOPSIDÆ.**

Cerithiopsis Bermudensis, sp. nov.

PLATE LXV. FIG. 20.

Shell slender, regularly tapered, composed of ten whorls besides the smooth, prominent, apical whorl. Whorls strongly convex in the middle, excavated above and below the suture so that the latter lies in a rather wide groove. Three prominent spiral cingula are situated on the middle or more prominent part of each whorl, the median one of which is slightly the most prominent ; just below the suture there is a fourth decidedly smaller one, often obsolete on the upper whorls ; on the last whorl there is a spiral carina resembling a fifth cingulum. These cingula are separated by concave grooves of about the same width, both are crossed by delicate costulæ which usually give a slightly nodulose appearance to the cingula. Base obliquely subtruncate, smooth. Aperture broad and short; outer lip broadly rounded, flaring anteriorly and projecting decidedly beyond the columella and separated from it by a deep notch. Columella slightly sigmoid. Color white or pale buff.

Length, about 4.5mm; breadth, about 1.3mm.

This common species resembles *C. metaxæ* Watson, but is stouter with a less attenuated spire, and differs somewhat in the character of the sculpture and in the larger size of the siphonal notch.

Found in the shell-sand.

Family CÆCIDÆ.

The following comparatively rare species were dredged in the Ship Channel and Bailey Bay, in 12 to 40 feet, with the very abundant *Cæcum termes* Heilprin and its varieties.

Section I.—Levia.—Shell smooth.

Cæcum tenue, sp. nov.

Plate LXV. Fig. 5.

Shell thin, translucent, slender, slightly curved, scarcely tapered, nearly smooth, with microscopic annular lines of growth. Aperture but little oblique, with a thin margin. Plug little prominent, obliquely truncated, most prominent close to the outer margin, without a mucro. Pale flesh color.

Length, about 1.6mm; diameter, about .35mm.

In shell-sand, rare.

Section II.—Annulata.—Shell annulated.

Cæcum tornatum, sp. nov.

Plate LXV. Fig. 1.

Shell slender, rather strongly curved, tapering a little, surrounded by eighteen to twenty-two strongly elevated, sub-acute cingula which, on the convex side, are rather narrower than the interstices, but on the concave side are of about the same width. Aperture round. Plug somewhat prominent, oblique, obtusely rounded, most prominent near the outer margin.

Some fresh specimens are somewhat translucent and often very pale flesh color, but most of the examples are opaque white.

Length, 2.5mm; diameter, 0.6mm.

A single specimen, apparently the young of this species, is more strongly curved, very slender, and strongly tapered toward the posterior end. It is surrounded by numerous, delicate, thin, prominent cingula, separated by wider spaces.

Rare in the shell-sand.

Section III.—**Costulata.**—Shell ribbed longitudinally.

Cæcum obesum, sp. nov.

Plate LXV. Fig. 3.

Shell thick, relatively short, stout, moderately curved, with about twelve strong, obtuse, longitudinal ribs, with wider, concave interstices; close to the anterior end these are decussated by several incised, revolving lines and close to the margin are replaced by two to six cingula, one of which is sometimes more elevated than the rest. Aperture round, unusually oblique, with a somewhat thickened margin. Plug with a small, prominent, oblique mucro, close to the outer margin. Color white, tinged with rusty brown.

Length, 2.5^{mm}; diameter, 0.75^{mm}.

Cæcum delicatulum, sp. nov.

Plate LXV. Fig. 4.

Shell small, thin, delicate, strongly curved, but little tapered, covered with numerous, fine, raised, longitudinal riblets, about as wide as their interstices. Near the margin, crossed by a number of fine, transverse lines, which form definite cingula close to the margin. Aperture nearly round, very oblique. Plug broadly exposed, oblique, most prominent near the outer margin, without a definite mucro. Color white.

Length, 2^{mm}; diameter, 0.5^{mm}.

Two young specimens, referred to this species, are strongly curved, regularly and rapidly narrowed posteriorly, with the surface, toward the larger end, minutely costulate, but smooth and translucent posteriorly. Plug just within the aperture, with a delicate spine close to the outer margin, visible only in profile.

In shell-sand, rare.

Cæcum debile, sp. nov.

Shell differing from *C. delicatulum* in having a prominent, nearly hemispherical plug and the surface covered by less numerous, very delicate, raised, longitudinal riblets, well separated but unequally spaced, crossed, near the margin, by very delicate well separated cingula, one of which, just below the edge, is more prominent than the others. Entire surface crossed by microscopic growth lines.

In shell-sand, rare.

Cæcum crispum, sp. nov.

Plate LXV. Fig. 3.

Shell slender, thin, delicate, strongly curved, covered with very fine, incised, longitudinal lines, which in some places are wavy, visible only with a lens. Toward the margin marked with several annular incised lines, with delicate intervening cingula. Aperture round, very oblique. Plug but slightly prominent, obtuse, with a small rounded mucro near the outer margin. Color white.

Length, 2.1^{mm}; diameter, 0.5^{mm}.

In shell-sand, rare.

Family **RISSOIDÆ.**

Alvania (Alvinia) pagodula Buq., Dautz. and Dollf.

Rissoa Philippiana Jeffreys, Ann. Mag. Nat. Hist., xvii, 2d series, p. 183, pl. ii, figs. 4, 5, 1856 (not *R. Philippiana* Nyst, 1845, nor *R. Philippii* Aradas, 1847). Name substituted but not adopted (Monterosato). Chenu, Manuel Conch., i, p. 307, f. 2169, 1859.

Rissoa (Alvinia) pagodula Buquoy, Dautzenberg and Dollf., Moll. Rouss., p. 296, pl. 56, figs. 23–26.

Alvania (Alvinia) Philippiana Monterosato, Conch., Med., p. 60, 1884.

Rissoa (Alvinia) pagodula Tryon, Manual Conch., ix, p. 366, pl. 66, f. 55, 1887.

Although specimens from Bermuda have but four whorls, they so agree in the form and character of the sculpture with descriptions of this species as to leave little doubt as to their identity.

In shell-sand.

Alvania (Alvinia) platycephala Dautz. and H. Fischer.

Plate LXV. Fig. 24.

Alvania platycephala Dautzenberg and H. Fischer, Mem. Soc. Zool., France, p. 63, pl. xix, figs. 12, 13, 1896.

In shell-sand.

Rissoa (Manzonia) Auberiana d'Orb.

Plate LXV. Fig. 17.

Rissoa Auberiana d'Orbigny, L'Ile de Cuba, ii, p. 22, Atlas, pl. xi, figs. 34, 36, 1853. Chenu, Manuel Conch., i, p. 307, f. 2170, 1859.

Rissoa (Alvania) Auberiana Mörch, Syn. Moll. Mar., p. 54, 1875.

Rissoa (Mangonia) Auberiana Tryon, Manual Conch., ix, p. 337, pl. 68, f. 85, 1887.

In shell-sand.

Rissoa (Manzonia) minuscula, sp. nov.

PLATE LXV. FIG. 16.

Shell very minute, pale yellowish brown, ovate, consisting of five whorls besides the small, mammillary, apical whorl. The whorls are convex in the middle; those of the spire are crossed by three revolving cingula and covered by numerous, fine, elevated, longitudinal costulæ, most distinct in the grooves between the cingula and on the subsutural area, giving the surface a finely cancellated appearance under the microscope; these costulæ do not interrupt the stronger revolving lines. The body-whorl is relatively large and has three or four smaller, additional revolving cingula below the periphery, the last of which circumscribes the narrow and shallow umbilical chink. Aperture round-ovate with a strongly thickened margin, supported by a well-developed marginal rib.

Length of the only specimen, 2.1^{mm}; breadth, 1.2^{mm}.

From the shell-sand.

Family **NATICIDÆ.**

Neverita duplicata (Say), 1822.

Natica duplicata Say; Gould, Invert. Mass., Binney Ed., p. 345, fig. 615, 1870. *Neverita duplicata* Verrill, Rep. on Invert. of Vineyard Sd., etc., pl. xxiii, fig. 130, 1873. Dall, Bull. U. S. Nat. Mus., No. 37, p. 154, pl. 51, f. 12, 1889.

One dead and broken specimen was found at Bailey Bay.

Family **VANIKORIDÆ.**

Vanikoro oxychone Mörch.

PLATE LXV. FIG. 6.

Vanikoro oxychone Mörch, Syn. Moll. Mar., p. 94, 1877. Tryon, Manual Conch., viii, p. 69, 1886.

Rare in the shell-sand.

RACHIGLOSSA.

Family **COLUMBELLIDÆ.**

Atilia monilifera (Sowerby).

PLATE LXV. FIG. 9.

Columbella (Atilia) monilifera Tryon, Manual Conch., v, p. 149, pl. 53, f. 100 (poor), 1883.

Common in the shell-sand.

Atilia Cumingii (Reeve), var. **acus** Reeve.

Columbella (*Atilia*) *Cumingii* Reeve, var. *acus* Tryon, Manual Conch., v, p. 151, pl. 53, f. 16, 1883.

Rather common in the shell-sand.

Æsopus Stearnsii (Tryon) Dall.

Plate LXV. Fig. 19.

Semicella Stearnsii Tryon, Manual Conch., v, p. 179, pl. 58, f. 48 (poor), 1883.
Æsopus Stearnsii Dall, Blake Report, pt. ii, p. 194, pl. xxix, f. 5, 1889; Bull. U. S. Nat. Mus., No. 37, p. 118, pl. 29, f. 5, 1889.

Very common in the shell-sand.

TOXOGLOSSA.

Family **PLEUROTOMIDÆ.**

Mangilia quadrata Reeve, var. **monocingulata** Dall ?

Mangilia quadrata Reeve, var. *monocingulata* Dall, Blake Report, pt. ii, p. 114, pl. xi, figs. 15, 16, 1889; Bull. U. S. Nat. Mus., No. 37, p. 102, pl. 11, figs. 15, 16, 1889.

One imperfect dead specimen from the Ship Channel, in 30–40 feet, agrees very closely with Dr. Dall's figure 15, quoted above. Neither the longitudinal ribs nor the spiral cingula are as prominent as in the type specimen of *Mangilia eritima* Bush, from Cape Hatteras, N. C., and the granular effect is entirely concealed by erosion.

Three other apparently undescribed species belonging to this family were also found in the shell-sand.

CEPHALOPODA.

Two species of *Octopus* were taken, in 1898, both of which have been previously recorded. The common large species is generally listed as *O. vulgaris*, but sometimes as *O. granulosus*, or *O. rugosus* Bosc, under the belief that this West Indian and Florida species is distinct from the European—a question that cannot be considered as settled at present. They are certainly very closely related.

The second, which is smaller and much less common, is *O. Bermudensis* Hoyle (Challenger Report, xvi, p. 94, pl. ii, fig. 5 = *O. chromatus* Heilprin, The Bermudas, pl. 15, fig. 1). It has very long slender arms, with a narrow basal web, and is very active. When living, its colors are bright and very changeable, but there are four or more larger round blue spots on its back which do not disappear.

Some of the native fishermen call it the "grass scuttle," and designate the common one as the "rock scuttle," by way of distinction.

Mr. G. Brown Goode obtained a very large squid, which was cast ashore at Bermuda in 1876. This was described and figured in 1880 and 1882* as *Sthenoteuthis pteropus* = *Ommastrephes pteropus* Steenstrup (?).

The Yale party, in 1898, secured one living specimen of another squid. It was captured in Bailey Bay, while swimming slowly at the surface. It appears to be *Sepioteuthis sepioidea* d'Orb., which was also taken at Bermuda by Goode and recorded in 1880 and 1882 by Verrill (op. cit.), but it has not appeared in later lists.

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* Verrill, these Trans., v, p. 228, pl. 27, figs. 7, 7*a*, pl. 36, figs. 5–9, 1880; Report U. S. Fish Com. for 1879 (pp. 107–111 of separata), pl. vii, fig. 2, pl. xvii, figs. 3–9, 1882.

EXPLANATION OF PLATES.

The figures on the following plates are reproductions of drawings by A. H. Verrill.

Plate LXIII.

Figure 1. *Tellina Candeana* d'Orb., p. 520. Sculpture. × 20.
Figure 2. The same. Left valve. × 3.
Figure 3. *Modiola* (*Botulina*) *opifex* Say, p. 516. Young. × 6.
Figure 4. *Lasœa Bermudensis* Bush, p. 518. Hinge of both valves. × 7.
Figure 5. The same. A left valve.
Figure 6. *Cardita Dominguensis* d'Orb., p. 517. A right valve. × 10.
Figure 7. The same. A left valve. × 10.
Figure 8. The same. Another valve. × 10.
Figure 9. *Coralliophaga coralliophaga* Gm., p. 520. Hinge of both valves. × 4.
Figure 10. The same. A right valve. × 3. The radial sculpture is more distinct than usual.
Figure 11. *Crassitellites* (*Crassinella*) *lunulata* (Conrad) var. *parva* C. B. Adams, p. 518. A right valve. × 8.
Figure 12. *Lucina nux* Verrill and Bush, p. 518. Type specimen. × 3½.
Figure 13. The same. × 5.
Figure 14. *Petricola* (*Naranaio*) *lapicida* (Gmel.), p. 519. Hinge. × 5.
Figure 15. The same. A right valve. × 5.

Plate LXIV.

Figure 1. *Tornatina decurrens* Verrill and Bush, p. 523. × 12.
Figure 2. *Tornatina recta* d'Orb., p. 523. × 12.
Figure 3. *Cylichna Auberi* d'Orb., p. 523. × 10.
Figure 4. *Bulla Bermudæ* Verrill and Bush, p. 523. × 3.
Figure 5. *Synaptocochlea picta* (d'Orb.) Pilsbry, p. 525. Adult. × 10.
Figure 6. *Haminea Antillarum* d'Orb., var. *Gaudalupensis* Sow., p. 524. × 8.
Figure 7. *Eulima engonia* Verrill and Bush, p. 527. × 5.
Figure 8. *Eulima amblytera* Verrill and Bush, p. 526. × 8.
Figure 9. *Eulima hypsela* Verrill and Bush, p. 526. × 4.
Figure 10. *Eulima atypha* Verrill and Bush, p. 528. × 9.
Figure 11. *Scala electa* Verrill and Bush, p. 536. × 3.
Figure 12. *Synaptocochlea picta* (d'Orb.) Pilsbry. Young specimen. × 10.
Figure 13. *Odostomia Jonesii* Verrill and Bush, p. 531. × 6.
Figure 14. *Odostomia ovuloides* C. B. Adams, p. 532. × 6.
Figure 15. *Odostomia lubrica* Verrill and Bush, p. 532. × 7.
Figure 16. *Eulima compsa* Verrill and Bush, p. 527. × 5.
Figure 17. *Scala uncinaticosta* d'Orb., p. 535. × 7.
Figure 17*a*. The same. Nucleus. × about 6.

Figure 18. *Turbonilla leuca* Bush, p. 529. × 15.
Figure 19. *Pyrgostelis puncta* (C. B. Adams) Bush, p. 530. × 15.
Figure 19*a*. The same. Sculpture much enlarged.
Figure 20. *Turbonilla valida* Verrill and Bush, p. 528. × 9.
Figure 21. *Turbonilla Swiftii* Bush, p. 529. Specimen No. 72,055 of Philadelphia Academy, from the West Indies. × 10.
Figure 21*a*. The same. Nucleus. × 37.5.

Plate LXV.

Figure 1. *Cœcum tornatum* Verrill and Bush, p. 537. × 15.
Figure 2. *Cœcum obesum* Verrill and Bush, p. 538. × 15.
Figure 3. *Cœcum crispum* Verrill and Bush, p. 539. × 15.
Figure 4. *Cœcum delicatulum* Verrill and Bush, p. 538. × 15.
Figure 5. *Cœcum tenue* Verrill and Bush, p. 537. × 13.
Figure 6. *Vanikoro oxychone* Mörch, p. 540. × about 15.
Figure 7. *Odostomia* (*Evalea*) *Somersi* Verrill and Bush, p. 533. × 12.
Figure 8. *Siphonaria henica* Verrill and Bush, p. 524. × 3.5.
Figure 9. *Atilia monilifera* Sow., p. 540. × 10.
Figure 10. *Cœcum termes* Heilprin, p. 537. Young. × 15.
Figure 11. *Odostoma* (*Cingulina*) *Babylonia* (C. B. Adams) Bush, p. 534. × 12.
Figure 12. *Turbonilla Heilprini* Bush, p. 528. × 12.
Figure 13. *Turbonilla Penistoni* Bush, p. 529. × 6; *a* nucleus. × 30.
Figure 14. *Odostomia* (*Cyclodostomia*) *didyma* Verrill and Bush, p. 533. × 18.
Figure 15. *Actæon punctostriatus* (C. B. Adams). × about 13. Off Cape Hatteras. Young. To show variation in size of nucleus.
Figure 16. *Rissoa* (*Manzonia*) *minuscula* Verrill and Bush, p. 540. × 12.
Figure 17. *Rissoa* (*Manzonia*) *Auberiana* d'Orb., p. 539. × 12.
Figure 18. *Actæon punctostriatus* (C. B. Adams), p. 522. Adult. × about 13.
Figure 19. *Æsopus Stearnsii* (Tryon) Dall, p. 541. Young. × 20.
Figure 20. *Cerithiopsis Bermudensis* Verrill and Bush, p. 536. × 10.
Figure 21. *Pyrgostelis* (*Mormula*) *pupoides* d'Orb., p. 531. × 12.
Figure 22. The same, var. *ischna* Bush, p. 531. × 8.
Figure 23. *Pyrgostelis* (*Mumiola*) *asperula* Bush, p. 530. × about 4.
Figure 24. *Alvania* (*Alvinia*) *platycephala* Daut. and H. Fischer, p. 539. × 12.

XIII.—The Nudibranchs and naked Tectibranchs of the Bermudas. By A. E. Verrill.

Hitherto these groups of Bermuda Mollusca have been much neglected. Heilprin (1889*) described a single new nudibranch (*Chromodoris zebra*, op. cit., p. 187), and the common ocellated *Aplysia* under a new name (*A. æquorea*, op. cit., p. 185) from a single small faded example. The latter is, however, clearly identical with a well known West Indian species originally described from the Cape Verde Islands, as *A. datylomela* Rang.

The Yale Expedition of 1898 obtained a large number of specimens of *A. dactylomela*, which is common both on the reefs and in the lagoons, and a few examples of two other much rarer species, one of which is very large and appears to be undescribed.

Aplysia megaptera, sp. nov.

Plate LXVI. Figure 6.

Body very large and robust; side-flaps unusually large and broad, each one nearly semicircular, entirely disunited posteriorly, and extending far forward, nearly to the rhinophores and rising abruptly on the neck, with the front margin well rounded; when expanded their breadth is greater than the length; when folded they broadly overlap above the back, with frilled margins. Foot broad, extending posteriorly only a short distance beyond the side-flaps, and abruptly tapered. Head short and thick. Tentacles large, with the anterior fold wide and crenulated. Rhinophores large, long-conical when closely folded. Anal siphon very large and broad, extending beyond the side-flaps when these are folded. A small nearly simple mantle-pore, with only a slight papilla. Shell thin and delicate. Gills large, deep purple.

Color, in life, dark olive-green, irregularly spotted and blotched with paler bluish green; most of the spots on the sides are rather small and oval or oblong, but some are large, not ocellated; on the inner surface of the side-flaps, the paler spots are much larger and more irregular; no black bars; shell-mantle dark purplish brown, with irregular pale spots.

* The Bermuda Islands, Philadelphia, 1889.

Length in life, 12 inches; height, with folded side-lobes, 5.5 inches; breadth across expanded side-lobes, or fins, 10 inches; length of latter, 7 inches; breadth of neck, at origin of side-lobes, 3 inches.

Bailey Bay, on reefs. It swims readily and strongly.

This species is larger and stouter than the common *A. dactylomela*, with much broader side-flaps, or fins. The latter species, in life, is usually lighter yellowish olive or greenish yellow, with ill-defined whitish spots and reticulated with narrow brown or black lines; and on the sides it has also rather large, roundish, ocellated spots of purplish brown, 6 to 12^{mm} across, with pale yellow or white centers, the dark linear reticulations usually crossing the spots; the inner surface of the side-flaps is greenish with about 6 or 7 large, irregular, often rather rectangular, transverse blotches or interrupted bars of dark chocolate-brown or black.

According to strict rules of priority this should doubtless be called *Tethys megaptera*, for Mr. Pilsbry has shown that *Tethys* was originally applied to the genus usually called *Aplysia*.

Aplysia (or **Tethys**) **Willcoxi** Heilprin (?).

Aplysia Willcoxi Heilprin, Proc. Acad. Nat. Sci., Philad., p. 364, 1886.
Tethys Willcoxi Pilsbry, Man. Conch., xvi, p. 80, pl. 35, figs. 30, 31, 32, 1896.

Plate LXVI. Figure 7.

A single specimen of a much smaller and plainer colored species was obtained, which I refer with some doubt to this Florida species.

The body is relatively longer and less robust than in either of the other species, and the foot extends considerably beyond the posterior end of the side-flaps. The latter are well rounded, moderately large, and nearly disunited posteriorly. The anal siphon is large and projects far beyond the side-flaps. Mantle-pore simple, subcentral. Oral tentacles large and very wide.

Colors were not noted in life, but only after being in formalin a short time, when they had probably changed very little. Sides and upper surface of neck, head, foot, tentacles, and outer surface of side-flaps, dull grayish brown, very irregularly blotched, mottled, and streaked with brownish black; top of head mostly black. Inner surface of side-flaps paler gray, with only a few irregular blotches of brown; gill dark brown.

Length, 6 inches (150^{mm}); length of side-flaps, 3.5 inches; breadth across latter, when expanded, 4 inches.

Bailey Bay, in shallow water. One example.

Pleurobranchopsis, gen. nov.

Body ovate, dorsum separated from the neck by a groove. Shell absent. Rhinophores elongated, folded. Oral tentacles conical. Gill lateral, attached along its entire length, or nearly so; no shell.

Allied to *Pleurobranchus*, but differs in lacking the shell and in the sessile gill. From *Pleurobranchæa* it differs in the gill, and the free anterior margin of the mantle.

Pleurobranchopsis aurantiaca, sp. nov.

Plate LXVI. Figure 5.

Mantle convex, smooth, with a free edge all around, forming a slight sinus at the gill. The gill arches upward and backward and is attached along its whole length. Foot wide, extends a short distance beyond the mantle posteriorly. Rhinophores slender, divergent, longer than the conical tentacles.

Color of entire upper surface bright orange, deeper orange-red on the mantle, which is finely specked with white and slightly translucent; foot, head and gill paler orange.

Length in life, in extension, 32 to 36^{mm} (about 1.75 inches); breadth, 18 to 20^{mm} (about .75 inch).

Coney Island at low-tide, among algæ. One example.

A cluster of eggs found at the same time and place, under a flat stone, is supposed to belong to this species. It is in the form of a broad gelatinous ribbon, attached by one edge and filled with numerous bright orange eggs in many rows.

Elysia crispa Mörch.

Plate LXVI. Figure 4.

This is a small, delicate, light green species, covered with small white specks and larger white spots or blotches, and a squarish white spot on the back of the head and neck, with prolongations into the rhinophores. Length 7–10^{mm}.

Among dead corals and on green algæ, 2 to 8 feet below low-tide. Bailey Bay, May 5.

Coryphella (?) pallida, sp. nov.

Body small, slender, dorsal papillæ long, slender, in two series of lateral clusters, numerous, not crowded, usually curved. Rhinophores elongated, tapered, slightly plicated, light yellow. Foot narrow,

its anterior lobes much prolonged, slender, acute, usually curved back.

Body white; dorsal papillæ dark gray with white tips.

Bailey Bay, in corallines; one example. Length 10mm.

Doris (?) bistellata, sp. nov.*

PLATE LXVI. FIGURE 2.

Body oblong-elliptical, rather thick and elevated, convex. Foot thick. Rhinophores clavate, plicated, retractile, without sheaths. Gills seven, retractile, pedunculated, some of them forked near the base, with few branches.

Proboscis large white, extensile.

Upper side rich dark purplish brown; back with two median large, irregularly stellate spots of flake-white, and with small scattered specks of white on body, head, gills, and sides of foot; under side of foot white with brown spots.

Length, 15 to 20mm; breadth, 6 to 8mm.

Castle Harbor, 2 to 4 feet, on reefs or dead corals, April 18.

Doris (?) olivacea, sp. nov.

Body small, in life elliptical or broad ovate, when at rest capable of considerable extension; both ends broadly rounded. Foot narrow, scarcely extending beyond mantle posteriorly. Mantle border wide, thin, undulated. Head lunate. Rhinophores small, conical, without sheaths, retractile. Gills retractile, numerous, slender, pinnate. Color pale green to dark olive-green above, with specks of dark green and with a darker green median patch; gills dark green; rhinophores dark olive-green; under side of mantle lighter green.

Length, 10mm; breadth, 6mm.

Bailey Bay, among corallines, April.

Lamellidoris lactea, sp. nov.

Body, in life, small, oblong elliptical, much depressed; edges of mantle thin, undulated. Dorsal surface little convex, covered rather uniformly with numerous small, obtuse, spiculose verrucæ.

* This and some of the other species are here referred doubtfully to the old genus *Doris*, because their anatomy and dentition have not been studied, owing to lack of more than one example in most cases. None of them belong to *Doris*, as now restricted.

Color nearly pure white. Length, in life, about 12mm. Probably young.

Bailey Bay Island, at low-water mark, among corallines. One example.

Lamellidoris (?) quadrimaculata, sp. nov.

Plate LXVI. Figure 3.

Body much flattened, broadly elliptical in life, with wide, thin, undulated mantle margins. Rhinophores conical, subacute, plicate, white, without distinct sheaths. Eyes small, nearer together than the rhinophores. Gills five, small, white, much branched. Back covered with minute spiculose papillæ, light orange-yellow with a darker orange wide median patch, and specked with numerous very small flake-white dots and with four larger, very distinct, prominent, round white spots, arranged in a quadrangle on the middle region of the back; numerous branching and reticulated thin white lines run out radially toward the margins of the mantle, above and below, and seem to be due to spicules imbedded in the tissues.

Length about 12mm; breadth, 6 to 8mm.

Castle Harbor, on dead corals, April 18. Two examples.

Chromodoris (?) roseopicta, sp. nov.

Plate LXVI. Figure 1.

Body broad-ovate, subtruncate in front, obtuse behind ; marginal ridges elevated and undulated in life. Gills rather large and numerous (about 16), elongated, simply pinnate. Rhinophores with a stout sheath. Dorsal area, except in middle, covered with rather numerous small conical papillæ, which form a single row behind the gills and near the front of head.

Ground-color of dorsum and sides bluish gray, but thickly specked with black and flake-white dots, these specks largest on the back; marginal ridge edged with bright carmine or rose-red, with a submarginal line of white; dorsal papillæ, rhinophore-sheaths, and tips of gills also carmine-red; outer margin of foot carmine or orange red.

Length, 25mm; breadth, 10mm.

Bailey Bay, just below low-tide mark, on rocks. One example, April.

EXPLANATION OF PLATE.

Plate LXVI.

Figure 1.—*Chromodoris roseopicta*, sp. nov. × 2.
Figure 2.—*Doris* (?) *bistellata*, sp. nov. × 3.
Figure 3.—*Lamellidoris* (?) *quadrimaculata*, sp. nov. × 3.
Figure 4.—*Elysia crispo.* × 4.
Figure 5.—*Pleurobranchopsis aurantiaca*, sp. nov. × 1½.
Figure 6.—*Aplysia megaptera*, sp. nov. ⅓.
Figure 7.—*Aplysia Willcoxi.* × ½.
Figure 8.—*Siphonaria henica* V. and B., sp. nov. × 4.

XIV.—Additions to the Anthozoa and Hydrozoa of the Bermudas. By A. E. Verrill.

ANTHOZOA.

Madreporaria.

A partial list of the corals collected at Bermuda (9 species) was published by J. M. Jones* in 1869. The identifications of his species were mostly made by the present writer, but his collection was very incomplete, and errors were made in printing the list. Another list (10 species) was also prepared by the writer for Prof. J. D. Dana† and published in 1872. Mr. A. Heilprin‡ also published a list of the Bermuda corals in 1889. His list included 19 species, of which I consider eight as spurious or mere varieties. The most extended list was prepared by J. J. Quelch for the Narrative of the Voyage of the Challenger (vol. i, part i, p. 146, foot note, 1885). This list included 23 species, but several of the six species of *Isophyllia* admitted by Quelch are scarcely more than individual variations of one species, not even worthy to be called varieties. Probably not more than two actual species of *Isophyllia* exist at Bermuda, and even these may eventually be united into one very variable species. I could detect no constant differences in the soft parts after a careful study of hundreds of living specimens, including all the varieties, though the color varies extremely, ranging through bright green, olive-green, gray, lavender, etc., all these colors being often found on a single example, distributed in regular patterns, or in irregular blotches, and generally they are varied with spots or blotches of flake-white.§ In some cases the color may be clear emerald-green, in others nearly clear lavender or gray, but some large examples were found that were half uniform green and half lavender without blotchings, the two colors being defined by a median plane. Nor

* Cont. to the Nat. Hist. of the Bermudas,. Trans. Nova Scotia Inst., 1869. Reprinted in Visitors' Guide to Bermuda, p. 145, 1876.

† Corals and Coral Islands, Ed. I, 1872; Ed. II, p. 114, 1874.

‡ The Bermuda Islands, Philad., 1889.

§ Some specimens were phosphorescent at night and this property seemed to be related to the white pigment.

do these colors depend to any great extent on the station, for in some cases all these variations may be found in one place. But those specimens found scattered in shallow water on bottoms of white shell-sand were usually gray, or pale lavender mottled with gray, though the hard parts do not differ from the darker colored ones. One of the commonest forms at Bermuda was named *Mussa fragilis* by Dana (Zoöph., p. 145, 1846). The type of this, from Bermuda, is still in the Museum of Yale University. This, which is the common more delicate form, should therefore bear the name *Isophyllia fragilis*. It is possible that the coarser *I. dipsacea* (D.) is only a variation of the same species, due to more vigorous growth.

Quelch also recognized seven species of *Oculina* from Bermuda, which is doubtless too many, for all the species are variable in form, the degree of elevation of the corallites, etc. Apparently all the Bermuda forms of *Oculina* can be reduced to four species. He also recorded two species of *Astræa* (*A. ananas* and *A. coarctata*). We found these two forms common in tide-pools, but consider them merely variations of one species (*A. ananas*).

So, likewise, we consider *Diploria Stokesii*, listed by Heilprin, as a mere variation of *D. cerebriformis*, with the ridges wider and more deeply grooved than usual. It is a common form.

Thus, at least eight nominal species should be eliminated from Quelch's list, leaving but 15 species. On the other hand he omitted one of the commonest species (*Porites astræoides*), recorded in other lists,* and *Siderastræa radians*, recorded by Jones. I have now to add three additional species of true reef corals, two of which (*Orbicella annularis* and *O. cavernosa*) are not uncommon and grow to large sizes. Thus the number of true anthozoan corals now known is about 20.

All these corals, except the *Plesiastræa*, herein described as new, are common West Indian and Florida species. The coral-fauna of Bermuda differs chiefly from that of the Florida reefs and the Bahamas in the absence of certain prominent and well known genera and species characteristic of the latter, especially the genera *Madrepora*, *Manicina*, *Colpophyllia*, *Eusmilia*, *Dichocœnia*, *Dendrogyra*, *Cladocora*, and the two very common species, *Mœandrina clivosa* and *Agaricia agaricites*. Possibly some of these may yet be discovered at Bermuda, but if found there at all they must be very local and rare, for the Bermuda corals have been extensively collected.

* See Richard Rathbun, Proc. U. S. Nat. Mus., 1887, p. 354.

Additional species of Bermuda Corals.

Orbicella annularis Dana.

Madrepora annularis Ellis and Sol., 1786.
Astræa annularis Lam., Anim. sans Vert., ii, 1816.
Heliastræa annularis Edw. and Haime, Corall., ii, 1849.
Astræa (*Orbicella*) *annularis* Dana, Zoöph., p. 214, pl. 10, fig. 6, 1846.
Orbicella annularis Verrill, Bull. Mus. Comp. Zoöl., I, p. 48, 1864. Pourtales, in Agassiz Rep. on Florida Reefs, Mem. Mus. Comp. Zoöl., vii, part I, pl. iv, figs. 1–10, 1880.

I have examined several large and characteristic examples of this species from the outer reefs of the Bermudas and also from the reefs in Great Sound, etc. Good specimens are in the American Museum, New York, and in the museum of the University of New York. The latter were obtained by Prof. Bristol's party. We obtained but one example.

The color in life is dull yellow. It does not differ from the Florida form.

Orbicella cavernosa (Esp.) Dana.

Madrepora cavernosa Esper., 1797.
Astræa argus Lam., Anim. sans Vert., ii, 1816.
Astræa (*Orbicella*) *argus* Dana, Zoöph., p. 207, pl. x, figs. 1*a*, 1*b*, 1846.
Heliastræa cavernosa Edw. and Haime, Corall., ii, 1857.
Orbicella cavernosa Verrill, Bull. Mus. Comp. Zoöl., I, p. 47, 1864.

The only specimen studied by me is a large hemispherical mass, in excellent condition, which formed part of the Bermuda exhibit, sent by the Governor of Bermuda to the Centennial Exposition at Philadelphia, in 1876, and afterwards presented to the U. S. National Museum. It is said to be not uncommon on the outer reefs near North Rocks.

Plesiastræa Goodei, sp. nov.

Plate LXVII. Figure 1.

Coral solid, massive, hemispherical, calicles circular, not very deep, pretty regularly arranged, near together, with their margins a little prominent and thickened. Septa prominent, nearly entire, usually 24, of which 12 are broad, reaching the columella, and alternate with 12 much narrower ones that extend only one-third the distance. The larger septa are vertical within, distinctly thickened distally, and bear thickened paliform lobes at the inner edge, close to the columella.

Columella solid, rather prominent, convex, circular or elliptical. Diameter of coral about 9 inches (225^{mm}); of calicles, 2.6^{mm} to 3^{mm}.

A single specimen of this fine species was collected at Bermuda by Mr. G. Brown Goode, in 1876.

Madracis decactis (Lyman, 1857), Verrill, 1864.

This species often grows in irregular masses composed of rounded nodules, easily broken apart. Although the coral has but ten equal septa, the animal has 20 regular but obtuse tentacles, in two cycles, differing a little in size and position (Pl. lxvii, fig. 10). The color, in life, is light orange-yellow or ochre-color. It is not rare.

Siderastræa siderea (Ellis and Sol.) Blainv.

This is very common in shallow water, both on the reefs and in the sounds, and it often grows in places where no other corals grow, owing to the turbidity of the water. It sometimes forms hemispheres over a foot across.

The figures of the polyps of this genus given by Agassiz (Florida Reefs) are not correct in representing the tentacles as three-lobed. They are simple, short, clavate or subcapitate, those of the different cycles quite unequal; a pair of small ones, each side of the base of a larger one, gave rise to the error in the figures drawn for Agassiz.

Figures of the animals of this and many of the other corals have been made for the final report on our Bermuda collection.

ACTINARIA.

A valuable paper on the Bermuda actinians was published by Prof. J. P. McMurrich in 1888–1887, with studies of the internal structure of most of the species. His list included five actinians* and five Zoanthidæ. One or two additional species were recorded from the Challenger Expedition.†

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* Proc. Acad. Nat. Sci., Philad., 1888, and reprinted in Heilprin's The Bermuda Islands, pp. 105–135, pl. 10, 11, 1889. Of the species enumerated "*Aiptasia* sp." is probably *A. tagetes; Oulactis fasciculata* is *Asteractis flosculifera* (Les.) Verrill, Amer. Journ. Sci., vii, p. 45, 1899 (*non* McMur.); *Phymactis crucifer* is *Epicystis crucifera* (Les.) Ehr.; Verrill, op. cit., vi, p. 496, 1898. The latter is a very large, handsome, pink and white species, with thickened, white transverse ridges on the inner side of the tentacles. It lives deeply buried in the crevices of the reefs.

† *Ilyanthopsis longifilis* Hertw., Rep. Zoöl. Voy. Challenger, xxvi, p. 13, pl. ii, fig. 12, was described from the Bermuda reefs.

It is shaped like *Aiptasia*, with a smooth column and collar: no acontia; 160 long tentacles and the same number of perfect mesenteries; a pedal disk; no sphincter muscle. Evidently allied to *Anthea* or *Anemonia*.

The most abundant species is *Condylactis passiflora* D. and M., which is often a foot across. Its body is red; tentacles very long, gray, tipped with pink or purple.

Our party added several interesting species to the list, some of which have already been recorded by me in the American Journ. Science.* The Zoanthidæ of our collection have not yet been fully studied, but they probably include one or two species, not included here, new to the fauna. The following are the species not definitely included in McMurrich's list. (See foot note above.)

Additional Actinaria.

Lebrunia Danæ (D. and M.) Verrill.

Oulactis Danæ Duch. and Mich., Corall. Antill, p. 47, pl. vii, fig. 10, 1860.
Lebrunea neglecta Duerden, Actin. Jamaica, p. 456, 1898 (*non* D. and M.).
Lebrunia Danæ Verrill, Amer. Journ. Sci., vii, p. 46, fig. 15, p. 48, 1899.

Plate LXVII. Figure 3. Plate LXIX. Figure 1.

Several large specimens, up to 8 inches in diameter, were found imbedded to the tentacles in crevices of the reefs. The arborescently branched, green, gill-like fronds (fig. 3) are very large and covered with many round, blue acrorhagi.

Actinotryx Sancti-Thomæ Duch. and Mich.

Corall. Antill., p. 45, pl. vii, fig. 2, 1860. Andres (*Actinothryx*), 1883. Duerden, Jamaican Actinaria, part ii, p. 148, pl. x, figs. 3–6, pl. xi, figs. 3, 4, pl. xii, fig. 3, 1900.

Rhodactis Sancti-Thomæ McMurrich, Actin. Bahama Is., p. 42, pl. i, fig. 9, pl. iv, figs. 2, 3, 1889.

Plate LXVIII. Figure 5.

Very common on the reefs, living exposed and usually gregariously, those in each group generally of the same color, and probably produced by fission from one parent stalk. The body is usually pear-shaped or top-shaped with a wide disk, covered with radial rows of small, lobed actinobranchs, diversified in color. Marginal tentacles are very small, unequal. It secretes a large quantity of mucus when irritated. The color is variable, usually brownish or purplish exteriorly. The base is smaller than the disk, often lobate, and very firmly adherent. The disk is but little contractile and not retractile.

* Vols. vi and vii. Brief Cont. to Zoöl., Nos. lviii–lxii, 1898, 1899.

Ricordea florida (D. and M.).

? Ricordea florida Duch. and Mich., Corall. Antill., p. 42, pl. vi, fig. 11, 1860. Duerden, op. cit., p. 156, pl. x, fig. 7, pl. xi, figs. 5, 6, pl. xii, figs. 1, 2, pl. xiii, fig. 1, 1900.

Heteranthus floridus McMurrich, op. cit., p. 47, pl. i, fig. 10, pl. iv, figs. 4, 5, 1889.

Habits and colors nearly the same as of the last.

It is possible that this is not the true *florida* of D. and M., but it appears to be the species described under this name by McMurrich. Duerden's species agrees better with the type of D. and M.

Epicystis osculifera (Les.) Ver.

Actinia osculifera Leseur, Journ. Philad. Acad. Sci., i, p. 175, 1817.

This species or variety scarcely differs from *E. crucifera*, except in lacking the transverse white ridges on the tentacles, characteristic of the latter. The colors of the two forms are similar and are variable in the same way in each.

Leseur's description seems to apply better to this than to any other known West Indian form. Duerden (op. cit., 1900, p. 139), considers this only a variety of *E. crucifera*.

Bunodactis stelloides (McMur.) Verrill.

Aulactinia stelloides McMurrich, Actinaria of Bahama Is, p. 28, pl. i, figs 5, 6, pl. iii, figs. 8–10, 1889.

Aulactinia stella Duerden, Journ. Inst. Jam., ii, p. 454, 1898 (*non* Verrill sp.).

Bunodella stelloides Verrill, Amer. Journ. Sci., vii, p. 43, Jan., 1898.

Bunodactis stelloides Verrill, op. cit., vii, p. 146, foot note, 1899.

Common under stones near low-tide mark.

SAGARTIADÆ.

Aiptasia annulata (Les.) Andres.

Actinia annulata Leseur, Journ. Philad. Acad., i, p. 172, 1817.

Aiptasia annulata Andres, Actinies, 1883. McMurrich, Actinaria Bahama Is., p. 7, pl. i, fig. 1, pl. iii, fig. 1, 1889.

PLATE LXVIII. FIGURE 3.

This species is not uncommon in the crevices of the reefs at and below low-tide. The largest examples were 8 inches or more in diameter when fully expanded and had several hundreds of tentacles. The color is generally light green with subspiral, raised, white annulations on the tentacles, which persist in preserved specimens.

Aiptasia tagetes (D. and M.) Andres.

Bartholomea tagetes Duch. and Mich., Supl. Corall. Antill., p. 39, pl. vi, fig. 16, 1866.
Aiptasia tagetes Andres, Actinies, 1883. McMurrich, Actin. Bahama Is., p. 12.

Plate LXVII. Figure 2.

Common at low-tide in crevices of the reefs. Usually green, or dark olive-green, with white specks.

Phellia rufa Verrill, sp. nov.

? *Phellia clavata* Duerden, Actin. Jamaica, p. 459, 1898 (*non* D. and Mich.*).

Plate LXVIII. Figure 2.

Column rather slender, usually cylindrical or nearly so, but often somewhat hour-glass-shaped; in expansion often three or four times as high as broad, the capitulum forming about one-fourth the height. Scapus covered with a thick, firmly adherent, tough coat of sand, etc., its upper edge slightly free and irregularly denticulated. Tentacles 36 to 48, in the larger examples, about as long as the diameter of the column or rather longer, the inner ones somewhat longer than the others, but not abruptly so, regularly tapered, subacute.

Color of scapus, under the sandy coat, dull brown; capitulum light rosy red to brick-red and flesh-color, translucent; tentacles variable, most often light terra-cotta red, or salmon-red, sometimes bright red, broadly tipped with reddish brown, and crossed by two or three broad, V-shaped or W-shaped reddish-brown bands, and with an elongated spot of the same color on each side of the base; disk similar to the tentacles in color, variegated with brown and flake-white spots, radially arranged.

Height of largest, 20 to 32^{mm}; diameter, 8 to 12^{mm} in expansion.

Common under and in crevices of stones and dead corals, just below low-tide mark (2 to 6 feet).

This agrees pretty closely with the Jamaican species described as *Phellia clavata* by Duerden, but not with the original account of that species.

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* The species described by Duch. and Mich. has the following synonymy:

Phellia Americana Verrill, Proc. Essex Inst., v, p. 327 [13].

Paractis clavata Duch. and Mich., Corall. Antilles, p. 40, pl. vi, figs. 7, 8, 1860 (*non Phellia clavata* Stimp., sp., 1855; Verrill, op. cit., iv, 1865, and vol. vi, pl. i, figs. 3–3*b*, 1869; *nec Phellia clavata* Duerden, Actinaria around Jamaica, Journ. Inst. Jamaica, ii, p. 459, 1898).

Capnea clavata Duch. and Mich., Supl., p. 33, 1866.

ANTHEADÆ.

Actinoides pallida (Duch. and Mich.) Duerden.

Anthopleura pallida Duch. and Mich., Corall. Antill., Supl., p. 126, 1866.
Actinoides pallida Duerden, Actin. around Jamaica, p. 453, 1898.

PLATE LXVIII. FIGURE 4.

This small species has vertical rows of verrucæ, only on the upper part of the column, decreasing downward, to which bits of shells were firmly adherent; usually there are about six in the larger rows; the upper one is more prominent and somewhat like an acrorhagus. It can usually be recognized by the chain of round or elliptical flake-white spots along the inner surface of the tentacles, bordered externally on each side by a narrow dark olive-green or brown line; some of the spots may touch each other, but they are mostly a little apart and united by a white line, while the dark lines are continuous and persist in preserved specimens after all other colors have faded.

The disk is variegated with green, brown, gray, and flake-white, the white being in the form of 12 or 24 squarish or oblong radial spots in front of the bases of the inner tentacles, and edged with brown radial lines; the lips are either green or white.

Not uncommon under stones at low-tide near Bailey Bay.

Actinia Bermudensis Verrill, Amer. Journ. Sci., vi, p. 495, 1898.

? *Diplactis Bermudensis* McMurrich, in The Bermuda Is., p. 116, pl. 10, figs. 4, 6, pl. 11, figs. 1, 2, 1889.

PLATE LXVII. FIGURE 7.

This is a common red species with a circle of large, round, blue acrorhagi close to the tentacular margin. Occasionally brownish yellow or rust-yellow specimens occur (*var. ferruginea* V.).

Prof. McMurrich has suggested (in letter) that it may prove to be the same as his *Diplactis*, the latter having been described from badly preserved specimens. If so his description certainly does not apply well to this species, which is a typical *Actinia*.

Common under stones at and above low-tide mark.

ALICIINÆ.

Bunodeopsis globulifera, sp. nov.

? *Viatrix globulifera* Duch. and Mich., Corall. Antill., p. 44, pl. vi, figs. 15, 16, 1860.
Verrill, Amer. Journ. Sci., vii, p. 146, fig. 20, 1899.
Bunodeopsis, sp. nov., Duerden, Actin. Jamaica, Journ. Inst. Jamaica, ii, p. 456.

Plate LXVII. Figure 4.

Column broad below, narrowed above; in the least contracted specimens the upper part is tapered to the tentacles and nearly free of tubercles; in others the column is short and covered with tubercles throughout, the naked part being concealed. The tubercles are smooth, rounded, and variable in size and number, larger and smaller ones are mingled together, but in general the lower ones are the larger. They are often very numerous over the lower half of the column and closely crowded. They are present in considerable number in specimens only 2^{mm} in diameter of column, but in such specimens they are mostly near the base. The limbus is strongly crenulated and lobed.

Tentacles, in full expansion, very long and slender, three or four times the diameter of the body, but they can contract to a much thicker, tapered form, about twice the diameter of the disk. They vary in number from 18 to 36, in the examples studied. Usually the number increases two at a time, for examples with 18, 20, 22, 24, and 26 tentacles were found. The twelve inner ones are longer than the others, and two rudimentary ones, just appearing, may often be found. In one case a forked tentacle was noticed. The disk is often nearly flat, but in many it protrudes in a conical form. The mouth is small, with two feeble siphonoglyphs.

Color in life yellowish green, often with dark brown streaks; vesicles yellowish brown. The largest examples are about 15^{mm} high and 8^{mm} broad at base.

Only a single example of this curious species was obtained by us, but a considerable number were collected by Prof. Bristol's party in 1898, which he has kindly loaned to me for study.

It lives attached to algæ in shallow water.

Mr. Duerden informs me that this is doubtless identical with his supposed new species. At first I thought that it would prove to be the adult of the long-sought *Viatrix globulifera,* but if so the latter was badly figured, for its vesicles are represented as close to the bases of the tentacles instead of confined to the lower part of the column. Therefore it seems best to consider it a new species.

EDWARDSIADÆ.

A species resembling an *Edwardsia* is contained in our collection, but it did not expand fully in life.

A specimen dredged in Flatt's Inlet, in 6 to 8 feet, sand, was reddish brown on the scapus, but it did not expose the tentacles. It has 8 fertile and muscular mesenteries with several pairs of small imperfect ones.

It needs to be studied more carefully by serial sections.

ZOANTHIDÆ.

Several species of Zoanthidæ have been described from Bermuda, and some additional forms were obtained by our party.

McMurrich, in 1889, described the five following species, all of which are, apparently, in our collection. His descriptions and figures are largely anatomical and histological.

Zoanthus flos-marinus (*non* Duch. and Mich.) = *Z. proteus* Ver. = ? *Z. Dancæ* Hert. (*non* Verrill).

Mammillifera tuberculata (Gray) = *Isaurus tuberculatus* Gray. McMur., 1896; Duerden, 1898.

Corticifera ocellata (*non* Ellis and Sol.) = *Palythoa grandiflora* Ver., sp. nov.

C. glareola (*non* Les., 1817) = *Palythoa mammillosa* (Ellis and Sol.) = *C. lutea* Hert. (*non* Quoy and Gaim.) = *P. mammillosa* Duerden, 1898.

Gemmaria Riisei (*Rusei* by error, *non* Duch. and Mich.) = *Parapalythoa Heilprini* Ver., sp. nov.

Hertwig (Rep. Voy. Chall., 1888) described *Zoanthus Dancæ?* (*non* Verrill), and *Corticifera lutea* (*non* Quoy and Gaim.) The former is perhaps our *Z. proteus;* the latter is our *Palythoa mammillosa.*

Additional Species.

Parazoanthus parasiticus (D. and M.).

Zoanthus parasiticus Duch. and Mich., Corall. Antill., p. 50, pl. viii, figs. 3, 4, 1860.

This minute species is frequently found parasitic on the tubular sponge (*Tuba* or *Spinosella vaginalis*). Only the disk shows at the surface of the sponge. When dried they appear as small, circular, about 12-rayed, stellate, and mostly separated spots, 1.5 to 2^{mm} in diameter, more or less scattered over the surface.

A variety or distinct species, with disks up to 3mm in diameter, occurs, more closely grouped, on a sponge of the genus *Hircina*.

Zoanthus sociatus Les., 1817.

Zoanthus sociatus McMurrich, Actin. Bahama Is., p. 62, pl. ii, fig. 3; pl. iv, figs. 15–18, 1889.

?Zoanthus flos-marinus Duerden, Jamaican Actin., part i, p. 339, pl. xviiA, fig. 2, pl. xviiiA, fig. 2, 1898 (*non* Duch. and Mich.).

Several specimens were obtained that seem to agree with this species as described by McMurrich, from the Bahamas, and with the *Z. flos-marinus* of Duerden. The latter has much smaller polyps than the original type of Duch. and Mich., and differs in form, color, and number of tentacles. (See p. 566, below.)

Zoanthus proteus, sp. nov.

?Zoanthus Danæ Hertwig (*non* Verrill).

Zoanthus flos-marinus McMurrich, The Bermuda Is., p. 119, pl. xi, figs. 3, 4, 1889.

Plate LXVII. Figures 5, 5*a*, 5*b*.

Polyps of moderate size, extremely variable in form and height, united into more or less extensive clusters either by slender narrow stolons, or by flat expansions of cœnenchyma, or directly, the buds often springing from the basal regions of the column, or even from higher up on the sides, so as to appear furcate or branched; sometimes stolons also arise from above the base. The polyps may be crowded or loosely aggregated; column may be short or long cylindrical; bottle-shaped; jug-shaped; club-shaped; or tall, slender, trumpet-shaped; all these forms often occurring in one cluster (see figs. 5–5*b*). The wall is soft, but often has dirt, grains of sand, etc., adhering slightly to the surface, except on the upper third or fourth part, which is smoother and naked, so that the surface is usually divisible into two regions; but this difference is not always evident. A constriction sometimes occurs between the two areas (fig. 5).

Tentacles numerous, slender, usually 48 to 52.

Color of column usually olive-green, sometimes bluish above; disk and tentacles pale ochre-yellow, with white specks, sometimes greenish.

Height of longest polyps, in contraction, 18mm; greatest diameter, 3.5 to 5mm; height of short forms, 4 to 6mm; diameter, 4 to 5mm; height of medium polyps, about 10mm; diameter, 3 to 5mm.

At and just below low-tide mark, on the reefs, adhering to stones and dead corals.

Zoanthus dubius Les., op. cit., p 1817 (*?non* D. and M.).

PLATE LXVII. FIGURE 9.

A few specimens were obtained on the reefs that appear to agree with this species. The polyps are often slightly clavate and distinctly smaller (about 4^{mm} diam.) than those of *Z. proteus* and *Z. sociatus* and form small open clusters, united by flat stolons. The lower part of the column is covered with sponges and other foreign substances; the upper part is soft and smooth.

Protopalythoa, nom. nov. Type *G. variabilis* Duerden.

Gemmaria Duch. and Mich.. Corall. Antill., p. 55, 1860, (*non* McCready, 1859).
Gemmaria McMurrich, The Berm. Is., p. 131, 1889; Actinaria Bahama Is., p. 64, 1889. Duerden, Jamaican Actinaria, i, p. 350, 1898.

The name *Gemmaria* having been preoccupied in Hydrozoa, it is necessary to give a new one to this group, if it is to be considered as really distinct from *Palythoa*, from which it seems to differ only in the fact that the zoöids are not united together laterally by cœnenchyma, but only by stolons or based expansions. Some species of *Palythoa* are not thus united for more than half their height, or even less, and perhaps future discoveries may show a complete gradation between the two conditions.

The sphincter muscle is single; the mesenteries are microtypic; the mesoglœa contains lacunæ; the walls contain grains of sand, etc., making them more or less coriaceous. The zoöids are sometimes monœcious; sometimes diœcious.

In renaming this genus I have intentionally assigned a new type, selecting the species which has been most fully described anatomically. The *first* species named by Duch. and Mich. (*P. Riisei*) was not figured and was so imperfectly described that it cannot be determined; not even the colors, nor the number of tentacles were given.

The second species (*P. clavata*) is said (1850) to have 30 tentacles, and to have a brown body and violet disk and tentacles. It seems to be very like *P. variabilis*, but the latter has 60 to 80 tentacles, and is larger.

Other closely allied species are *P. isolata* McMur., Bahamas; *P. fusca* Duerden, Jamaica; *P. McMurrichi* Hadd. and Shackl.; *P. Mutuki* H. and S.; *P. Canariensis* H. and Duerd.; *P. Heilprini* Ver. = *G. Riisei* McM. (*non* D. & M.), see p. 560. The affinities of *G. brevis* D. and M. are uncertain.

Protopalythoa grandis, sp. nov.

PLATE LXVII. FIGURE 6.

A large species with the polyps united into small divergent clusters by short stolons, furcate at the base, or sometimes isolated; walls thickly encrusted with fine sand. Column in expansion usually clavate, obconic, or long trumpet-shaped, with the basal part tapered and rather narrow; often two to three times as high as broad. Disk broad, cup-shaped or when fully expanded convex or umbrella-shaped, with the borders recurved. Tentacles numerous, about 60 to 66, in two alternating rows, all similar, short, obtuse; outside the tentacles is a circle of marginal papillæ, nearly as large as the tentacles and alternating with the outer row. Sometimes one tentacle (directive), in line with the long axis of the mouth, was larger and lighter colored than the rest.

Color of column usually pale orange, salmon, or buff, under the coat of white sand; disk usually rich orange or orange-brown, sometimes light orange, buff, or ochre-yellow, the tint often varying in the same cluster, its outer part, near the tentacles, darker than the central, and usually with darker radial lines, sometimes tinged with green; lips white or orange; tentacles like disk, but usually a shade paler, often darker at base, but the tentacles may be darker than the disk in pale specimens.

Height of largest polyps, 30 to 36^{mm}; diameter of expanded disk, 12 to 16^{mm}.

On dead *Oculina*, off Bailey Bay, 30 to 40 feet; Harrington Sound, 2 to 6 feet; also in shallow water on the reefs, not common.

Decidedly larger than either of the species hitherto described from the Atlantic.

Palythoa Lamx., Polyp. flex., 1816.

Corticifera Leseur, Journ. Acad. Sci., Philad., i, p. 178, 1817.

This genus differs from *Protopalythoa* only in having the polyps united laterally, to a greater or less extent, by cœnenchyma filled with sand and other foreign substances, so as to form continuous coriaceous crusts, often of great extent.

The mesenteries are microtypical,* as in *Zoanthus*, and usually not very numerous.

* McMurrich, evidently by error, states that they are macrotypical (Actin. Bahama Is., p. 62), but he describes them as microtypical on a later page (p. 66).

Two species of this genus are common and often found together, on the rocks at low-tide, in tide pools, or even in exposed situations, where they are often laid bare by the tide. Both are buff or pale ochre-color and thickly encrusted with whitish sand. The more common is the species described as *Corticifera lutea* by Hertwig and as *C. glareola* by McMurrich. As indicated above (p. 560), neither of these names is correct. The zoöids are decidedly larger and the tentacles (36–38) more numerous than in *P. glareola*. It forms broad encrustations, often one to three feet in diameter, varying in thickness up to one-half an inch or more (10 to 15^{mm}), with the zoöids 6 to 8^{mm} in diameter when expanded, or 6 to 7^{mm} in contraction, and projecting, when fully contracted, only very slightly or not at all above the cœnenchyma, but in partial expansion forming more or less prominent verrucæ, often nearly as high as broad. All these various conditions can often be seen in the same cluster. Pl. lxviii, fig. 7.

This appears to be the earliest described species, *Palythoa mammillosa* (Ellis and Sol., 1780), of which their second species (*ocellata*) was perhaps a synonym, differing only in the state of preservation.

The other Bermuda species, remarkable for the large size of the polyps and the extent to which they are free distally, appears to be undescribed. (*P. grandiflora* V.)

We did not find the real *Palythoa glareola* Les., at Bermuda. It is distinguished mainly by the smaller size of the polyps (diam. 4^{mm} contracted) and the fewer mesenteries and tentacles (24, t. Les.; 28–34 t. Duerd.). Perfect mesenteries about 16–17, often unsymmetrical (t. Duerd.); 17 (t. Les., fig.). Disk violet (t. Les.).

Its appearance and mode of growth are nearly the same as in *P. mammillosa*, but it forms thinner crusts (about 5–8^{mm}), though perhaps of equal extent. It was well described and figured, with anatomical details, by Leseur (op. cit., pp. 178, 184, 185, pl. viii, figs. 6–9, 1817), and more fully, with histology, by Duerden (Jamaican Actinaria, i, p. 365, pl. viii A, fig. 9, pl. xix, figs. 5–7, 1898) as *P. Caribœa* D. and M.

Palythoa grandiflora, sp. nov.

Plate LXVIII. Figure 6.

Zoöids large, often free distally for about half their entire length, and forming clusters (usually of 12 to 24) several inches across. In contraction the zoöids form large, rounded mammillæ, often higher than broad, strongly sulcated longitudinally, the grooves (about 26) converging to the central depression of the summit; sur-

face covered with a firm coat of fine sand. In partial expansion, the summit becomes considerably swollen or turbinate; in full expansion, broad saucer-shaped. Tentacles about 52 to 56 or more, short, subequal, with half as many marginal denticles.

Color buff or light ochre to dark ochre; disk dull orange or brownish yellow, usually marked with radial lines and specks of white; tentacles dull orange, often tipped with white; marginal denticles, flake-white.

Height of zoöids, 15 to 20^{mm}; diameter in contraction, 10 to 13^{mm}; disk, in expansion, 14 to 16^{mm}.

This species has larger zoöids and much more numerous tentacles than any hitherto described.

It is probably the species described as *Corticifera ocellata* by McMurrich (Bermuda Is., p. 127), but not the original *ocellata*.

As additional species of West Indian *Zoanthi* are likely to occur at the Bermudas, I add, for convenience, the following analytical table, based chiefly on the external characters given in the *original* figures and descriptions, but supplemented in some cases by the observations of later writers (as indicated), and by personal studies. Valuable diagnostic characters are undoubtedly to be derived from anatomical and histological studies, especially from the character of the sphincter muscles and the musculature of the mesenteries. But at present only a few species have been studied in these respects and some of those that have been thus studied have evidently been erroneously identified, so that these characters cannot be used advantageously in this table. Moreover the individual variations in their anatomy, known to be great, have not been sufficiently investigated in any species. The size and form of the sphincter muscles vary according to the degree of contraction and mode of preservation. For such characters reference should be had to the plates of McMurrich and of Duerden. The number of tentacles is equal to that of the mesenteries, but as the latter are added by pairs, bilaterally, next the directives, the number varies considerably, even in polyps that seem adult.*

I do not pretend to vouch for the specific distinctness of all the nominal species included in this table, but they are the forms usually regarded as distinct.

* This mode of increase and the bilateral arrangement of the mesenteries was first definitely described by the present writer in these Transactions, vol. i, pp. 495, 496, 1869, as characteristic of the entire family. Leseur had figured them correctly as early as 1817. Probably the number of *perfect* mesenteries will be found more constant than the total number, but this has seldom been given by writers on this group.

Analytical table of West Indian Species of Zoanthus.

A.—Tentacles short, subequal, in two alternating series.

B.—Cœnenchyma mostly in the form of tubular or band-like stolons.

C.—Tentacles 50 to 60, or more.

d.—Column usually clavate and pedunculate; stolons mostly tubular; clusters open.

e.—Greatest diameter of column usually 4 to 5^{mm}; height 25^{mm} or less, column usually bluish green or violaceous distally; prevailing color of disk, green or blue, variegated or radially spotted with brown. *Z. sociatus* Les.

ee.—Greatest diameter of column 11^{mm}; expanded disk 13–14^{mm}; height of column up to 50^{mm} or more. Prevailing colors of column yellowish or reddish; of disk and tentacles, yellowish, reddish, or red-brown. Test "coriaceous": "ovaries, 20" (t. Leseur). *Z. Solandri* Les. (type).

dd.—Column usually nearly cylindrical, not distinctly pedunculate; stolons mostly flat and band-like; clusters close, exposed. Size "one-third smaller than *sociatus*" (t. Les.). *Z. dubius* Les. (type).

CC.—Tentacles 48–52. Column protean, may be cylindrical, jug-shaped, subclavate, and trumpet-shaped in one colony. Stolons variable, mostly narrow. Diameter of column, usually 5 to 6^{mm}; height up to 20^{mm}, mostly less. Prevailing color of disk and tentacles, green. Test with a rough cuticle proximally. *Z. proteus* Ver.

CCC.—Tentacles about 36. Size large. Column somewhat clavate, but with a wide base. Clusters open. Diameter of column distally about 15^{mm}; its height up to 35^{mm}; diameter of expanded polyp, 20^{mm}; length of tentacles, 2.5^{mm} (t. fig. by Duch. and Mich.). Column greenish distally; a ring of green around the mouth. *Z. flos-marinus* D. and M. (type).

BB.—Cœnenchyma mostly lamellar or membranous, polyps short, clusters usually rather close.

f.—Column short, usually obovate, swollen, pedunculate. *Mammillifera* Les.

Tentacles about 52–60.* About 60 mesenteries, of which 27 are perfect and bear ovaries (t. Leseur, p. 184, and pl. viii, fig. 3). Diameter of column, in contraction, about 6^{mm}; in expansion about 7^{mm}; height, 7–8^{mm}. Test "soft and smooth." Disk greenish; tentacles and column reddish (t. Les.).

Z. auricula (Les.).

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* Leseur, on p. 178, Journ. Phil. Acad., i, 1817, gives the number of tentacles as 26–30, but this is evidently an error, probably due to the fact that only one cycle was shown in the drawing. In his remarkably accurate transverse section he shows 61 mesenteries, and also indicates the directives, the inequality of the pairs, and the *bilateral arrangement* of the later pairs,—features that were ignored by later writers for nearly half a century! (See these Trans., i, p. 495.) As the number of tentacles, in this family, corresponds to the mesenteries, it is safe to assume that 52 to 60 are the usual numbers. McMurrich and others have been misled by this error (see McMurrich in Ann. N. York Acad., ix, p. 189, 1876).

ff.—Column cylindrical or subclavate, with a rather stout base.

g.—Tentacles about 50 (t. Les.); 56–62 (t. McMur.). Column short, nearly cylindrical; diameter in contraction, 3–4^{mm}; height, 2–3.5^{mm} (t. McMur.). Disk yellowish, a green circle at base of tentacles; tentacles light brown; mouth rosaceous (t. Les.). Test soft and smooth, but with a cuticle (t. McMur.). Hermaphrodite. *Z. nymphœa* (Les.).

gg.—Polyps larger; column more elongated, cylindrical or only slightly clavate.

h.—Tentacles small and very numerous. Diameter of column, in contraction, 5–6^{mm}; disk, in expansion, 8–9^{mm}; height of column, 10–12^{mm} (t. fig. by D. and M.). Cœnenchyma thick, fleshy. Clusters rather open. *Z. Anduzii* (D. and M.).

hh.—Tentacles about 60. Perfect mesenteries 26–28. Column wall thin, with a cuticle below, carrying foreign matter. Diameter of column, in contraction, about 6^{mm}; of fully expanded disk, 8–10^{mm}; height of column, 4–30^{mm}, average about 13^{mm}. Clusters rather close. Cœnenchyma thin, tough, lamellar. Colors variable; column, pale below, olive-blue above; tentacles usually dark brown, sometimes green or olive; disk usually bright green with paler radial lines, sometimes pale green or yellow, sometimes a dark triangular spot in line with each angle of mouth; peristome pink, bright green, or yellow. Becomes dark green in alcohol (t. Duerd.). Hemaphrodite. Sphincter muscle distinct from that of *Z. nymphœa* (t. Duerd.). *Z. pulchellus* Duerden.

(*M. distans* and *M. pulchellus* (both of D. and M., Supl., 1864), St. Thomas, were originally too imperfectly described, and as intimated by their authors, may be only varieties of *Z. nymphœa*.)

AA.—Tentacles long and slender, recurved, about 60, their length 8^{mm}, as figured. Polyps large, clavate, pedunculate, 40–42^{mm} high; diameter of column distally, in contraction, 8^{mm}; of expanded disk, without tentacles, 10^{mm}. Tentacles blue. *Z. nobilis* D. and M.

(This may be an *Epizoanthus*, which it resembles in the length and slenderness of its tentacles. Its anatomy is unknown.)

ALCYONARIA.

GORGONACEA.

Lists of the Gorgonacea have been published by J. M. Jones, J. D. Dana, Heilprin, and others, but none of them are very complete. Heilprin gives nine species, but two of them are probably mere varieties. The following valid species are in Heilprin's list (Bermuda Is., p. 103).

Gorgonia flabellum Linn. Sea-fan.

Gorgonia acerosa (?) Pallas. Purple sea-plume.

Gorgonia Americana Gmel. (Recorded by Dana.) Sea-plume.

Plexaura flexuosa Lamx. Sea-rod.

This is one of the largest as well as the most common species. It becomes two feet or more broad and often three feet or more high, with a very large main stem, two or three inches in diameter. The branches are furcate with very numerous terminal branchlets, 4 to 6^{mm} in diameter. The calicles are small, round, not crowded, with the borders only very slightly raised or not all so. Color in life, dull dark purple or grayish brown; when dried usually purple-brown, often brownish yellow, or a combination between these colors.

Plexaura homomalla (Esp.) Lamx. Black sea-rod.

Plexaurella crassa (Ellis and Sol.) Lamx. = *multicauda* Heilp. Sea-rod or sea-whip.

See pl. lxix, fig. 4. Remarkable for the very large size and elegance of the polyps, which cannot be retracted; but in life they completely conceal the coral and make it look like a soft branching sponge. The pores are large, open, and close together when dry.

Plexaurella dichotoma (Esp.) Kölliker.

Easily recognized by its long, stout cylindrical or digitate branches, covered with very irregularly shaped pores, which may be narrow-oblong, elliptical, oval, or circular, with the long axis in various directions and with lips only slightly raised or not at all.

The *Gorgonia purpurea* and *G. pseudo-antipathes* of Heilprin's list are indeterminable. The former is probably the purple variety of *Plexaura flexuosa*.

Gorgonia turgida (Ehr.) Verrill, has been recorded from Bermuda by the present writer (Amer. Journ. Sci., xlviii, p. 424, 1869).

Additional Species of Gorgonacea.

Gorgonia citrina Esper., 1794.

Gorgonia citrina Esper, Die Pflanzenth., ii, p. 129, pl. xxxviii, figs. 1, 2, 1794.
Gorgonia (*Pterogorgia*) *citrina* Dana, Zoöph., 1846.
Xiphigorgia citrina Verrill, Bull. Mus. Comp. Zoöl., i. p. 33, 1864.

Several specimens of this small, flat-branched species were obtained by our party in 1898. Both varieties, yellow and purple, occur but most examples are tinged with both these colors.

Gorgonia setosa Linn. Purple sea-plume.

A single perfect specimen of this fine species is in our collection. Others, of large size, but imperfect, were seen in local collections. It may be only a variety of *G. acerosa* Pallas.

Muricea muricata (Pallas) Verrill.

Gorgonia muricata Pallas, Elench. Zoöph., p. 198, 1766. Ellis and Sol., 1780.
Muricea spicifera Lamx., Exp. Method., pl. 71, figs. 1, 2, 1821.
Muricea muricata Verrill, Amer. Journ. Sci., xlv, p. 411, 1868.

Numerous fine specimens of this species were obtained, in 1898, by the Yale party, on a small reef in Bailey Bay, a few feet below low-tide, by diving. It completely covered one small reef. It was also found on the reefs in Castle Harbor, but only sparingly. In life, its color is yellowish brown to ochre-yellow, with beautiful translucent, white or buff, elongated polyps, which become so exsert in expansion that they entirely conceal the coral, their length equal to the diameter of the branches. When dried the color is pale buff or ochre, sometimes tinged with rust-brown. The lower lip of the calicles projects strongly and the whole surface is very spiculose, some of the superficial spicules being very large and irregularly fusiform.

Figure 1.—*Muricea muricata.* ×5

Eunicea ramulosa Ehr., 1834.

Gorgonia spicifera Dana, Zoöph., 1846.

A few specimens of this were seen in local collections, but none were taken by our party. The branches are slender and arise laterally or pinnately from the main stems.

Eunicea grandis, sp. nov.

PLATE LXIX. FIGURES 3, 3*a*.

A very large species, with long, round, thick, digitate or furcate, rigid branches, which taper but little distally and usually lie somewhat in one plane, thus forming corals one to two feet broad and sometimes nearly three feet high. Axis nearly cylindrical, dark brown or black, osseous at base. Cœnenchyma very thick and hard, filled with fusiform spicules of moderate size.

Calicles, in dried specimens, not much elevated, usually forming low convex verrucæ, with a small, terminal, indistinctly eight-lobed aperture; sometimes with a large round opening having the edges a little elevated.

Color when dried brownish black, dark umber-brown, or yellowish brown. In life umber-brown or sepia-brown, sometimes tinged with purplish or yellow.

The very large exsert zoöids expand freely in confinement and then the calicles are more prominent, and evidently 8-lobed. The expanded zoöids are swollen, somewhat translucent, dark russet-brown or yellowish brown, paler than the cœnenchyma, with a white line on the outside of tentacles, due to spicules; mouth bordered with white. The tentacles are much stiffened by spicules and contract slowly.

Diameter of main stalk often 2 to 3 inches, at base; diameter of digitate branches about .50 to .75 inch (12 to 18^{mm} or more), their length 6 to 12 inches.

Not uncommon in 6 to 20 feet, on the reefs.

This species is similar to *E. Rousseaui* Edw., in size and appearance, but that species has a prominent lower lip to the large calicles. Our species appears to be a larger, much stouter and more branched form.

Eunicea Tourneforti Edw., Corall., i, p. 150, 1857.

? Gorgonia madrepora Dana, Zoöph., p. 671, 1846.

PLATE LXIX. FIGURES 2, 2*a*, 2*b*.

This species grows in forms similar to the last, but it is smaller, with the branchlets about 7 to 12^{mm} in diameter. The calicles are more prominent, oblique, with the aperture on the upper side and the lower lip prolonged, as in the calicles of madrepores.

Color dark umber-brown or black when dried; dark brown or sepia-color in life.

Eunicea Rousseaui M. Edw. and Haime.

Corallieres, vol. i, p. 151, 1857. Verrill, Bull. Mus. Comp. Zoöl., i, p. 36, 1864. *Gorgonia pseudo-antipathes* (*pars*) Dana, Zoöph. (*non* Esper).

This is also a large species with stout, forked, digitate branches, nearly as in the last, but larger. The calicles are large, rounded, somewhat elevated, directed obliquely upward, and with the lower lip a little prolonged.

Diameter of digitate branchlets 12 to 18^{mm}; their length, 150 to 300^{mm} (6 to 12 inches).

Color when dried, dark umber-brown or blackish.

Only a few specimens were obtained.

HYDROZOA.

This group has been studied but little at the Bermudas. Mr. J. Walter Fewkes* has published a descriptive list of 26 free Hydrozoa and 4 Ctenophora observed by him during a brief visit to Bermuda. Some of these were new species, but several are known from the New England coast and farther south.

Our party collected very few free forms and added to the list only the common *Porpita Linnæana*.

Attached hydroids are not numerous, either in species or individuals, only about 6 species of sertularians, 3 campanularians, one plumularian, and one tubularian having been collected by us.

The tubularian is *Pennaria tiarella*, found also on the American coast northward to Cape Cod. All the sertularians appear to be well known West Indian species.

The most common sertularian appears to be *Sertulariella Gayi*. It was taken with gonothecæ.

All the numerous specimens of *Millepora* seen by us could be referred to the common polymorphous species, *M. alcicornis*, though *M. ramosa* has been recorded from there by Quelch (Voy. Challenger, Narrative, i, p. 146, note.

* On a few Medusæ from the Bermudas, Bull. Mus. Comp. Zoöl., vol. xi, pp. 79–90, pl. xi, No. 3, 1883.

EXPLANATION OF PLATES.

Plate LXVII.

Figure 1.—*Plesiastræa Goodei*, sp. nov. Group of calicles. ×4.
Figure 2.—*Aiptasia tagetes.* ×1½.
Figure 3.—*Lebrunia Danæ.* One of the actinobranchs. ½.
Figure 4.—*Bunodeopsis globulifera*, sp. nov. ×2.
Figure 5.—*Zoanthus proteus*, sp. nov. Two of the more elongated polyps. ×2.
Figure 5*a*.—The same. Group of polyps from the same specimen as 5.
Figure 5*b*.—The same. Short polyps from the same colony.
Figure 6.—*Protopalythoa grandis*, sp. nov. ×2.
Figure 7.—*Actinia Bermudensis* Ver. About natural size.
Figure 8.—*Madracis decactis* Lym. Group of calicles. ×6.
Figure 9.—*Zoanthus dubius.* Base is overgrown with sponge. ×2.
Figure 10.—*Madracis decactis* Lym. Group of living polyps, enlarged about 10 times.

Plate LXVIII.

Figure 1.—*Actinactis flosculifera.* Side view. ×1½. *b*. Three of the pseudofronds, more enlarged.
Figure 2.—*Phellia rufa*, sp. nov. ×1½.
Figure 3.—*Aiptasia annulata.* Three tentacles of different cycles, much enlarged.
Figure 4.—*Actinoides pallida; a*, fully expanded; *b*, partially expanded; *c*, one of the tentacles, inner surface, more enlarged.
Figure 5.—*Actinotryx Sancti-Thomæ.* Oblique view; enlarged about 1½.
Figure 6.—*Palythoa grandiflora*, sp. nov. Polyps contracted. Cluster, natural size. Photographed from a specimen in formalin.
Figure 7.—*Palythoa mammillosa.* Part of a cluster. Some of the polyps are more or less expanded, others are entirely retracted. Natural size. Photographed from a specimen preserved in formalin.

Plate LXIX.

Figure 1.—*Lebrunia Danæ.* Oral side. About natural size.
Figure 2.—*Eunicea Tourneforti.* Side view of part of a branch. ×3.
Figure 2*a*.—The same. Section of branch. ×3.
Figure 2*b*.—The same. Portion of a section, more enlarged, to show spicules.
Figure 3.—*Eunicea grandis* Ver., sp. nov. Part of branch. ×3.
Figure 3*a*.—The same. Section of a branch. ×3.
Figure 4.—*Plexaura crassa.* Surface of a part of a dried branch to show the large open calicles. ×3.

XV.—Additions to the Crustacea and Pycnogonida of the Bermudas. By A. E. Verrill.

CRUSTACEA.

The collection of Crustacea obtained by the Yale party in 1898 contains nearly all the species recorded from there by previous writers, and many that are new to the fauna. Of marine Isopoda and Amphipoda about 50 species were collected, but they have not yet been carefully studied. Very few of them have been reported from Bermuda.

Lists of the Bermuda decapod Crustacea have been published by J. M. Jones,* A. Heilprin, and in the several Reports on the Zoölogy of the Challenger Expedition, but they are all quite incomplete. Mr. W. M. Rankin† has very recently published a more extensive catalogue of the Bermuda Decapoda. His list contains 56 species of this group.

Our 1898 collection and those collected by J. M. Jones ; G. Brown Goode ; C. Hartt Merriam ; F. V. Hamlin and others, now in the Yale Museum, include about 20 species of Decapoda not contained in Mr. Rankin's list, so that the total number now known is about 75. Nearly all of these are also West Indian species.

To these may be added *Geryon incertus* Miers, dredged in deep water off Bermuda by the Challenger Exp.

A number of the smaller and more difficult species have been sent to Miss M. J. Rathbun of the U. S. National Museum for determination, and to her I am much indebted for aid of this kind, as indicated under particular species. A few are still undetermined.

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* Mr. Jones sent to the Yale Museum, about 1877, a valuable collection of Bermuda Crustacea collected by himself, during several years of residence there. It contains a large example of the great land crab, *Cardisoma Guanhumi*. I was informed that this species still occurs at Cooper's Island, but not elsewhere. We had no opportunity to collect at that locality.

† Annals New York Acad. Sci., xii, No. 12, pp. 521–548, May, 1900. This list is based on the collections made by Prof. Bristol's parties in 1897–1898, but it includes, also, those that were collected by Mr. G. Brown Goode, and most of those obtained by the Challenger Expedition; some that have been enumerated by Heilprin and others are omitted.

Additional Decapod Crustacea.

BRACHYURA.

GRAPSIDÆ.

Geograpsus lividus (Edw.) Stimp.

Grapsus lividus A. Milne Edw., Hist. Nat. des Crust., ii, p. 85, 1837; Melang. Carcinol., p. 135.
Geograpsus lividus Stimpson, Proc. Acad. Nat. Sci., Philad., 1858, p. 101; Notes on North Amer. Crust., Annals Lyc. Nat. Hist., N. York, vii, p. 230, 1860. Kingsley, Proc. Acad. Nat. Sci., Philad., p. 195, 1880 (description).

This species, in life, has the carapax light brownish yellow or pale brown, marked irregularly with brownish black bands and streaks.

Two adult specimens were taken in 1898; Mr. Goode also obtained one example. West Indies.

A closely related form (*G. occidentalis* St.) considered identical by Kingsley, occurs on the west coast of America, from Cape St. Lucas to Chili.

Sesarma Miersi Rathbun.

Synopsis Amer. Sesarmæ, Proc. Biol. Soc. Wash., xi, p. 91, 1897.

Miss Rathbun refers one young specimen to this species with some doubt (coll. 1898). Bahamas,—Rathbun.

Sesarma Ricordi M. Edw.

Ann. Sci. Nat., Ser. 3, vol. xx, p. 183, 1853. Kingsley, Proc. Acad. Nat. Sci., Philad., for 1880, p. 217. Rathbun, Synopsis Sesarmæ, p. 91.

Miss M. J. Rathbun identifies the very common Bermuda *Sesarma* as this species. It is doubtless listed by Mr. Rankin and others as *S. cinerea*. Whether the true *S. cinerea* is also found there is doubtful. Our numerous examples all appear to be of one species, though they vary much in color. Common on the shores under stones and among dead algæ, nearly up to high-tide mark.

Plagusia depressa (Fabr.) Say.

Cancer depressus Fabr., Ent. Syst., Supl., p. 406, 1775.
Plagusia Sayi DeKay, N. York Fauna, p. 16. Stimpson, Notes on N. Amer. Crust., i, p. 18 [64]; ii, p. 104 [232].
Plagusia depressa Say, Journ. Acad. Nat. Sci. Philad., i, p. 100, 1817. Rathbun, Dec. Crust. W. Africa, p. 281, 1900 (distribution). Miers, Rep. Voy. Chall., xvii, p. 272, 1886.

This species is commonly seen running with great rapidity over the rough ledges and cliffs, above high-tide mark, in the same manner as *Gapsus grapsus*, but it is even more alert and swifter in its motions, so that its capture is difficult.

It was taken by us on Castle Island and Bailey Bay Island, in 1898.

Percnon planissimum (Herbst).

Cancer planissimus Herbst, Naturh. Krebb., p. 3, pl. lix, fig. 3, 1804.
Acanthopus planissimus Stimpson, op. cit., p. 104 [242], 1860.
Acanthopus Gibbesii Milne Edw., Mel. Carcin., p. 146.
Leiolophus planissimus Miers, Catal. Crust. N. Y., p. 46, 1876.
Percnon planissimum Rathbun, Dec. Crust. W. Africa, Proc. U. S. Nat. Mus., xxii, p. 281, 1900.

Very common in some localities under stones at low-tide; a situation for which its very flat body is admirably adapted. Also received from J. M. Jones, Mr. Goode and others.

CANCRIDÆ.

Leptodius Floridanus (Gibbes) A. M. Edw.

Chlorodius Floridanus Gibbes, Proc. Am. Assoc. Adv. Sci., iii, p. 175, 1850. Stimpson, Notes on N. Amer. Crust., Annals Lyc. Nat. Hist. N. York, vii, p. 209. S. I. Smith, Trans. Conn. Acad., ii, p. 3, 1869.
Leptodius Floridanus A. M. Edw., Miss. Sci. Mex., v, vol. i, p. 268, pl. xlix, fig. 2, 1873.

Several specimens were collected in 1898. It ranges to Aspinwall and Brazil.

Heteractæa ceratopus (Stimp.) A. M. Edw.

Pilumnus ceratopus Stimpson, Annals Lyc. Nat. Hist. New York, vii, p. 215 [87], 1862; and x, 1871.
Heteractæa ceratopus A. Milne-Edw., Sci. Miss. Mexico, part v, i, p. 300, pl. lii, figs. 3-3*d*.

One adult example taken in shallow water, 1898. Florida to Guadeloupe.

Xanthodius parvulus (Fabr.) t. Rathbun.

Chlorodius Americanus Saussure, Mem. de la Soc. Phys. et d'Hist. Nat. Genève, vol. xiv, p. 430, pl. i, fig. 5, 1857.

Xanthodius Americanus Stimp., Notes on N. Amer. Crust., Ann. Lyc. Nat. Hist., N. York, vii, p. 81, 1860.

Leptodius Americanus A. Milne Edw., Miss. Sci. Mex., v, i, p. 269, 1873.

A single adult specimen,—coll. F. V. Hamlin. Florida reefs to the Antilles. Hayti (Saussure).

Miss M. J. Rathbun informs me that she has identified this species by comparison with the original type of *Cancer parvulus* Fabr. in the Museum of Copenhagen, and that it belongs to the genus *Xanthodius*.

Eupanopeus occidentalis (Saussure) Rathbun.

Panopeus occidentalis Saussure, Rev. et Mag. Zoöl., ii, ix, p. 502, 1857; Mem. Soc. Phys. Genève, xiv, p. 431, pl. i, fig. 6, 1857. A. M. Edw., Miss. Sci., Mexico, v, i, p. 310, 1880. Benedict and Rathb., Proc. U. S. Nat. Mus., xiv, p. 360, 1891.

Eupanopeus occidentalis Rath., Bull. Labr. N. Hist. Univ., Iowa, iv, p. 273, 1898.

Miss Rathbun identifies one young example (No. 3021, Yale Mus.) as this species. South Carolina and Florida to Trinidad.

Eupanopeus serratus (Saussure) Rathbun.

Panopeus serratus Saussure, Rev. et Mag. Zoöl., ii, ix, p. 502, 1857; Mem. Soc. Phys. Genève, xiv, p. 432, pl. i, fig. 7, 1857. S. I. Smith, Proc. Boston Soc. Nat. Hist., xii, p. 280, 1869. A. M. Edw., Miss. Sci. Mexico, v, i, p. 311, 1880. Benedict and Rathbun, The Genus Panopeus, Proc. U. S. Nat. Mus., xiv, p. 371, 1891.

Panopeus Herbstii, var. *serratus* Miers, Rep. Voy. Chall. Zoöl., xvii, p. 129, 1886.

Eupanopeus serratus Rathbun, Bull. Labr. Nat. Hist., Univ. of Iowa, iv, p. 273, 1898.

A species was recorded under this name from Bermuda by Heilprin, and by Miers, but at that time the much more common species (*E. Bermudensis* Ben. and Rath., 1891), had not been distinguished, so that it is uncertain whether he really had this species. Rankin did not find it in the collections studied by him.

An example of this species from our collection (No. 3119), has been identified by Miss Rathbun by direct comparison with a photograph of Saussure's type.

Liomera dispar (Stimp.) Rathbun.

Chlorodius dispar Stimp., Prelim. Rep. on Crust. Gulf Stream, Bull. Mus. Comp. Zoöl., ii, p. 140.
Leptodius dispar A. M. Edw., Miss. Sci., Mex., v, i, p. 271, 1880.

Two males of this rare species have been identified by Miss Rathbun (No. 3176, Yale Mus.).

Pilumnus spinipes (A. M. Edw.) Rathbun.

Micropanope spinipes A. M. Edw., Miss. Sci., Mexico, v, i, p. 326, pl. liv, fig. 3, 1880.
Pilumnus spinipes Rathbun, Bull. Labr. Nat. Hist. Univ. Iowa, iv, p. 264, 1898.

Two specimens of this rare species were taken by our party, in 1898. Cuba (Edw.).

PORTUNIDÆ.

Portunus (Achelous) Ordwayi (Stimp.).

Achelous Ordwayi Stimpson, Notes on N. Amer. Crust., ii, p. 96 [224], 1860. S. I. Smith, Trans. Conn. Acad. Sci., ii, p. 9, 1869 (descr.).

Several specimens, mostly collected by J. M. Jones, are in the Yale Museum. They have been determined by Miss Rathbun. It was not taken by our party. It ranges southward to Brazil (Smith).

MAIIDÆ.

Mithrax depressus A. M. Edw.

Mithrax depressus A. Milne Edw., Mission Sci., Mexico, part v, i, p. 96, pl. xx, fig. 4, 1880.

A single young specimen (No. 3019, Yale Mus.) has been identified as this species by Miss Rathbun. Florida to Guadeloupe.

Stenorhynchus sagittarius (Fabr., 1793).

Leptopodia sagittaria Leach, Zoöl. Miscell., ii, pl. lxvii, 1816. Latreille, Encycl. Meth., Insects, pl. 299, fig. 1, 1818. Desm., Consid. Crust., p. 155, pl. xvi, fig. 2, 1825. Latr. in R. Anim., Cuvier, ed. ii, pl. iv, 1829. Milne Edw., Ill. ed. Cuv., Crust., pl. xxxvi, fig. 1. A. M. Edw., Mission Sci., Mex., part v, vol. i, p. 172, 1873.

Mr. Goode, while in Bermuda, sent to Prof. S. I. Smith a characteristic drawing of this species made from a specimen in the local collection of the late Mr. Bartram of St. Georges. This collection

now belongs to the Bermuda government, but was mostly inaccessible at the time of our visit. The drawing, however, leaves no doubt of the identification.

Cape Hatteras to the West Indies and to Bahia, Brazil; Madeira; Cape Verde and Canary Is.; West Africa; west coast of America.

Chorinus heros (Herbst) Leach.

Cancer heros Herbst, Krabben und Krebse, pl. xlii, fig. 1; pl. xviii, fig. 102.
Chorinus heros M. Edw., in Cuvier, Illust. ed., Crust., pl. xxix, fig. 2. A. M. Edw., Miss. Scient., Mex., part v, vol. i, p. 86, 1873.

One specimen (No. 3126, Yale Mus., coll. J. M. Jones), determined by Miss Rathbun. Key West to Barbadoes. Rare.

ANOMURA.

PAGURIDÆ.

Calcinus sulcatus (M. Edw.).

Pagurus sulcatus M. Edw., Ann. Sci. Nat., ser. 2, vi, p. 279, 1836; Hist. Nat. Crust., ii, p. 230.
Calcinus sulcatus Stimpson, Proc. Acad. Nat. Sci., Philad., 1858, p. 234. S. I. Smith, These Trans., ii, p. 17, 1869.

Several specimens of this species are in the collection, determined by Miss Rathbun. It ranges southward to Brazil (Smith).

Petrocheirus insignis (Sauss.).

Pagurus insignis Saussure.

Two specimens from our collection have been determined by Miss Rathbun. One was collected many years ago by Mr. F. V. Hamlin.

Paguristes (?), sp. indet.

Six specimens of an undetermined species, which Miss Rathbun thinks may be undescribed, are in the Yale Museum, collected by Mr. Hamlin.

MACRURA.

ALPHEIDÆ.

Alpheus formosus Gibbes, Proc. Amer. Assoc., iii, 1851.

Alpheus Poeyi Guerin, Sagra's Hist. isle de Cuba, l, p. xix, pl. ii, fig. 10, 10*a*, 1857.

This species is one of the most common in cavities in dead coral. Recorded also by Heilprin. Possibly *A. Websteri* Kingsley is the same.

Synalpheus lævimanus, longicarpus (Herrick).

This species has been identified by Miss M. J. Rathbun, from specimens in the U. S. Nat. Museum.

Athanas Ortmanni Rankin.

Annals New York Acad. Sci., xi, p. 251, pl. xxx, fig. 7, 1898.

Identified by Miss M. J. Rathbun from specimens in the U. S. Nat. Museum.

PALÆMONIDÆ.

Palæmon Savignyi (Bate).

Brachycarpus Savignyi Bate, Macrura, Voy. Challenger, xxiv, p. 795, pl. cxxix, 1888.

Palæmon Savignyi Rankin, Crust. Bahamas, Annals New York Acad. Sci., xi, p. 244, 1898.

Reported from Bermuda by Bate; from Nassau, N. P. by Rankin.

Latreutes ensiferus (M. Edw.) Stimp.

Latreutes ensiferus Stimpson, Proc. Acad. Nat. Sci., Philad., p. 27, 1860. Bate, Rep. Zoöl. Voy. Chall., xxiv, p. 583, pl. 104, figs. 1–1*g*.

Common among gulf-weed.

PONTONIDÆ.

Several specimens of an undetermined shrimp belonging to this family are in the Yale collection (No. 3080).

Periclimenes Americanus (Kings.) t. Rathbun.

Anchistia Americana Kingsley, Proc. Acad. Nat. Sci., Philad., 1878, p. 8; Bull. Essex Inst., x, p. 65.

Numerous Bermuda specimens of this species, from several different collections, are in the Yale Museum, determined by Prof. S. I. Smith and Miss Rathbun. It is common. Key West,—Kingsley.

PENÆIDÆ.

Penæus Braziliensis (Latr.).

Nouv. Dict. d'Hist. Nat., xxv, p. 154. M. Edw., Hist. Nat. Crust., ii, p. 414. Gibbes, Proc. Amer. Assoc. Adv. Sci., 1850, p. 198. Stimpson, Notes on N. Amer. Crust., iii, p. 132, 1871. Smith, These Trans., ii, p. 27.

A single specimen from Mr. Goode's collection. It ranges from New York to Bahia and Rio Grande do Sul, Brazil, and to West Africa.

Sicyonia dorsalis Kingsley.

Proc. Acad. Nat. Sci., Philad., 1878, p. 97; Bull. Essex Inst., x, p. 69.

One example determined by Miss Rathbun. It may, perhaps, be identical with "*S. carinata?*," recorded by Rankin. Florida,—Kingsley.

SCHIZOPODA.

MYSIDÆ.

Heteromysis Bermudensis G. O. Sars.

Rep. Zoöl. Voy. Challenger, xiii, p. 216, pl. xxxviii, figs. 1–7, 1885.

Shallow water with *Paranebalia longipes* (t. Sars).

PYCNOGONIDA.

No species of this group has hitherto been reported from Bermuda, so far as known to the writer. Our party obtained two small species in 1898.

Ammothea (?) rugulosa, sp. nov. **Ammothella,** subgenus nov.

Plate LXX. Figure 9.

A small rudely spinulose species covered with adhering dirt. Body elliptical of moderate width, abdomen small. Proboscis large, fusiform, much swollen in the middle, large at the distal end, longer than half the length of the body. Eye-tubercle rather large, subclavate, with a rather large, brown, 4-lobed eye-spot at the rounded tip. Legs crooked, covered with rough spinules; 3 basal joints short; 4th and 5th longer, a little swollen; 6th longer and more slender; 7th very short; 8th strongly curved; dactylus strong and much curved; two accessory claws and several smaller spinules. Palpi long and slender, tapered, extending much beyond proboscis, 10-jointed; 1st and 3d joints short; 2d and 4th long; last 6 subequal, very well defined, rather short; the four last fusiform, the terminal one a little the longer and thinner. Antennæ nearly as long as the proboscis, 3-jointed, spinulose, two basal joints long, 2d stouter, clavate; dactylus very small, forming a very small chela. Accessory legs nearly concealed by several clusters of eggs, 9-jointed, 2 basals and 3 terminals very short; 3–6 longer. Length of body and proboscis 2^{mm}; of proboscis 0.75^{mm}.

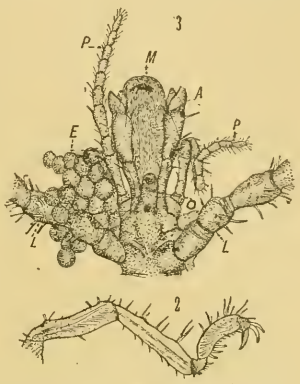

Figure 2.—*Ammothea* (*Ammothella*) *rugulosa;* part of leg much enlarged.

Figure 3.—The same. Anterior parts enlarged; A, antenna; P, palpus; M, mouth and proboscis; O, eye-tubercle; E, eggs; L, L. anterior legs.

One specimen, Bailey Bay, low-tide.

This species differs from typical *Ammothea* in having the palpi 10-jointed instead of 8-jointed. The number of joints in the accessory legs was not made out very clearly, but 9 joints were visible.

Achelia (?) gracilis, sp. nov.

Plate LXX. Figure 10.

A small, slender species, minutely spinulose, with very slender, moderately long legs. Body rather narrow-elliptical, proboscis rather large, fusiform, tapering to a small, rounded distal end, its aperture with curved, chitinous hooks. Antennæ short, almost rudimentary, apparently 2-jointed and minutely chelate. Eye-cone small, rather high and narrow, obtuse, oblong-conic with minute terminal papillæ; eyes very small, brown. Abdomen small, slender, slightly fusiform and turned up; bilobed at end.

Figure 4.—*Achelia? gracilis;* part of leg, much enlarged.

Legs slender, with a strong dactylus and accessory claws; 3 basal joints short; 4th much longer, decidedly swollen; 5th and 6th about as long and much more slender. Accessory legs slender, apparently 12-jointed, including a minute terminal joint with 2 claws; 11 joints distinct.

Palpi little longer than proboscis, not very slender, spinulose, apparently 8-jointed or perhaps obscurely 9-jointed; 2d and 4th joints long; 5th (6th?) and last very short; next to last a little longer, rather thick (5th and 6th perhaps not distinct).

Length of body and proboscis, 1.25^{mm}.

One specimen, Flatts Inlet, dredged in shallow water.

This does not belong to restricted *Achelia*, on account of having only 8 definite palpal joints (instead of 9), and apparently 12 in the accessory legs (instead of 10); and in having the antennæ obscurely chelate.

XVI.—Additions to the Echinoderms of the Bermudas.

By A. E. Verrill.

ECHINODERMATA.

A list of the species of echinoderms known from Bermuda has recently been published by Mr. H. L. Clark.* In this list he enumerated 28 species, but admitted that four or five of the holothurians are doubtful; an opinion in which I fully concur. Of Ophiuroidea he listed seven species.† Our collection increases the number of species in this group to 18.

Most of these have already been recorded by me,‡ and some of them had previously been recorded by Mr. Theod. Lyman (Rep. Voy. Challenger, V.).

We obtained nearly all the recorded echinoids and starfishes, except *Luidia clathrata*, and apparently all the known holothurians, but we did not add any species to the lists of these groups except in the case of the holothurians. Our holothurians have not yet been fully studied, but a small green *Synapta* was taken that has not been recorded from Bermuda. This appears to be the *Synapta viridis* Pourtales, described from the Florida coast in 1851, but apparently not since rediscovered.

Synapta vivipara was found common in a great variety of situations—under stones, in dead coral, buried in sand, etc. In life it is brownish red.

The large black *Stichopus*, named *S. diaboli* by Heilprin, was found very abundantly everywhere on the white shell-sand bottoms down to at least 50 feet deep. It is exceedingly hard to preserve it by any method tried by us, either in alcohol or formalin solutions. Possibly ice-cold alcohol might have succeeded, if there had been

* Notes on the Echinoderms of Bermuda, Annals New York Acad. Sci., xi, pp. 407–413, 1898. Based on the collection made by Prof. Bristol's party.

† The species recorded by Mr. Clark are as follows: *Ophiura appressa; Ophiactis Mülleri; Ophiostigma isacanthum* (two with 6 arms and 1 with five arms were taken by us in 1898); *Ophionereis reticulata*, common; *Ophiocoma echinata* (=*crassispina* Say), common; *O. pumila* (both 6-rayed and 5-rayed forms were found common by us, 1898); *Ophiomyxa flaccida*, common. All these were also collected by the Yale party, 1898. All of these, except the first, had also been recorded by Heilprin.

‡ These Trans., vol. x, Faunal Catalogue, Ophiuroidea from the West Indian Region, pp. 372–377, 1899.

facilities for keeping it cold for several days, as we had successfully done with several large, gelatinous, deep-sea species of holothurians on former occasions.

The spotted *Stichopus* (*S. xanthomela* Heilp.) is much less common, and it is also difficult to preserve, though we succeeded fairly well with some of the smaller specimens in alcohol. I am not prepared to express a decided opinion as to its specific distinctness, for I have not yet studied it with care. It is referred to *S. Möbii* Semper, by Clark. We observed only these two forms of *Stichopus*.

No crinoids have been positively recorded, though Sir W. Thomson (Narrative Voy. Challenger) mentions seeing a mutilated specimen of the rare genus *Holopus* in a local collection at Bermuda. Very likely it occurs in deep water, outside the reefs.

The total number of echinoderms now known from the Bermudas is about 40, all of which seem to be identical with West Indian species.

The small variety of true starfishes is remarkable, for only four species are known, and two of these are very rare. *Asterias tenuispina* is the only common species, though the little polygonal *Asterina folium* is not rarely found under stones at low-tide. It is usually pale blue in life, a very unusual color among echinoderms. The others, *Luidia clathrata* and *Ophidiaster Guildingii*, are very rare.

Additional Species of Echinoderms.

OPHIUROIDEA.

In the following list the sequence and nomenclature used is the same as in my Faunal Catalogue (This vol., p. 372).

PECTINURIDÆ Ver. (This vol., pp. 303, 372.)

Ophiura brevicauda (Lütk.) Lyman.

Ophioderma brevicauda Lütken, Vidensk. Meddel., Jan., 1856, p. 8; Addit. ad Hist. Ophiur., pt. ii, p. 94, pl. 1, figs. 3–3*e*, 1859.

Ophiura brevicauda Lyman, Illust. Catal. Mus. Comp. Zoöl., i, p. 16, 1865. Verrill, Notes on Radiata, Trans. Conn. Acad., i, p. 342, 1868. Lyman, Report Voy. Challenger, Zoöl., Ophiuroidea, v, p. 9, 1882.

Crevices in the reefs; not common, 1898. Florida and West Indies to South America.

Ophiura cinerea (Müll. and Tr.) Lyman.

Ophioderma cinereum Mull. and Troschel, Syst. Aster., p. 87, 1842.

Ophioderma Antillarum Lutk., Vid. Meddel., p. 9, 1856; Add. ad Hist. Ophiur., pt. ii, p. 88, pl. i, figs. 1*a*-1*e*, 1859.

Ophiura cinerea Lyman, Illust. Catal. Mus. Comp. Zoöl., i, p. 27, 1865; Lyman, Report Voy. Challenger, Zoöl., Ophiuroidea, v, p. 9, 1882; Bulletin Mus. Comp. Zoöl., x, p. 230. Verrill, Notes on Radiata, Trans. Conn. Acad., i, p. 342, 368, 1868. Nutting, Narrative Bahama Exp., p. 131.

Interstices and crevices of the reefs. Taken by the Yale party, 1898, and by G. Brown Goode.

Florida reefs to Bahia, Brazil.

OPHIOLEPIDIDÆ Ljung.

Ophiolepis paucispina Müll. and Tr.

Ophiura paucispina Say, Journ. Acad. Nat. Sci., Philad., v, p. 149, 1825.

Ophiolepis paucispina Müll. and Trosch., Syst. Aster., p. 90, 1842. Lütken, Addit. Hist. Ophiur., ii, p. 102, pl. ii, figs. 2*a*, 2*b*, 1859. Lyman, Illust. Catal. Mus. Comp. Zoöl., i, p. 55, 1865.

Two specimens were dredged in Bailey Bay, 20 to 30 feet, shell-sand, 1898. Florida to Rio de Janeiro.

OPHIOTHRICHIDÆ Ljung.

Ophiothrix angulata (Say) Ayres.

Ophiura angulata Say, Journ. Phil. Acad. Nat. Sci., v, p. 145, 1825.

Ophiothrix violacea Müll. and Trosch., Syst. Aster., p. 115, 1842. Lyman, Ill. Cat. Mus. Comp. Zoöl., i, p. 164. Lütken, Add. ad Hist. Oph., pt. ii, p. 150, pl. iv, figs. 1–1*d*, 1859. Verrill, Trans. Conn. Acad., i, p. 342, 366, 1868.

Ophiura hispida Ayers, Proc. Bost. Soc. Nat. Hist., iv, p. 249, 1852.

Ophiothrix angulata Ayers, Proc. Bost. Soc. N. Hist., iv, p. 249, 1852. Lyman, Illust. Cat. Mus. Comp. Zoöl., i, p. 162, pl. i, figs. 1–3, 1865; Report Voy. Challenger, Zoöl., Ophiuroidea, v, pp. 216, 219, 1882; Bull. Mus. Comp. Zoöl., x, p. 267, 1883. Verrill, Bull. Labor. Nat. Hist. Univ. Iowa, v, p. 19, 1899 (descr.).

Not common. It often lives gregariously among sponges. Cape Hatteras to Rio Janeiro, Brazil. Off Cuba, 200 fath.

Ophiothrix Suensonii Lütken.

Ophiothrix Suensonii Lütken, Vid. Meddel., p. 15, 1856; Add. ad Hist. Oph., pt. ii, p. 148, pl. iv, fig. 2. Lyman, Bull. Mus. Comp. Zoöl., v, 9, p. 232; op. cit., x, p. 267. Verrill, Trans. Conn. Acad., i, p. 342, 1868. Lyman, Report Voy. Challenger, Zoöl., Ophiuroidea, v, p. 222, 1882. Nutting, Narrative Bahama Exp., p. 221 (colors). Verrill, Bull. Labor. Nat. Hist., Univ. Iowa, v, p. 21, 1899 (descr. colors, etc.).

Collected at Bermuda by Mr. G. Brown Goode.

OPHIOCOMIDÆ Ljung., 1867.

Ophiocoma Riisei Lütken.

Ophiocoma Riisei Lütken, Vid. Meddel., p. 14, Jan., 1856; Add. ad Hist. Oph., pt. ii, p. 143, pl. iv, fig. 6. Lyman, Ill. Cat. Mus. Comp. Zoöl., i, p. 76. Verrill, Trans. Conn. Acad., i, pt. 2, p. 341, 1868. Lyman, Report Voy. Challenger, Zoöl., Ophiuroidea, v, p. 171, 1882.

Common from Florida and the Bermudas, throughout the West Indies, to Colon and to Brazil.

This is a large black species. It is easily distinguished from *O. echinata*, found in the same localities, by its long, slender, upper arm-spines, which in the latter are stout, blunt, swollen in the middle.

Ophiopsila Riisei Lütken.

Ophiopsila Riisei Lütken, Add. ad Hist. Oph., pt. ii, p. 136, pl. v, fig. 2, 1859. Lyman, Illust. Catal. Mus. Comp. Zoöl., i, p. 150, figs. 16, 17, 1865; Bull. Mus. Comp. Zoöl., v, 9, 228. Verrill, Notes on Radiata, Trans. Conn. Acad., i, p. 341, 1868. Lyman, Report Voy. Challenger, Zoöl., Ophiuroidea, v, p. 160, pl. xl, figs. 1–3, 1882 (anatomy).

Florida Reefs to Brazil, shore to 57 fath. Bermuda (Lyman).

AMPHIURIDÆ Ljung., 1867.

Ophiactis Krebsii Lütken.

Ophiactis Krebsii Lütken, Vid. Meddel., p. 12, 1856; Addit. ad Hist. Oph., pt. ii, p. 126. Lyman, Ill. Cat., i, p. 111, figs. 10, 11. Verrill, Notes on Radiata, Trans. Conn. Acad., i, p. 341, 366, 1868; Bull. Labor. Nat. Hist. Univ. Iowa, v, p. 34, 1899.

Ophiactis Savignyi (*pars*) Lyman, Report Voy. Challenger. Zoöl., Ophiuroidea, v, p. 115, 1882.

Mr. Lyman, in his later works, considered this identical with *O. Savignyi* and *O. virescens*, from the Indian and Pacific oceans respectively. With this opinion I am not able to agree.

This, like most other species of the genus, usually has six or seven arms when young, and it increases by spontaneous fission. It is green, variegated with white or gray. It lives in the interstices of sponges and corals, often gregariously while young.

Common in sponges and interstices of dead corals. Charleston, S. C., and Florida Reefs to Rio de Janeiro, Brazil.

Amphipholis Ljung. (restricted). Type, **A. squamata** (= *A. elegans*).

Two small lateral oral-papillæ, and one broad, operculiform, distal one, forming a continuous series along each side of the jaws, and capable of nearly or quite closing the mouth-slits. Radial shields in close contact.

Amphipholis tenera (Ltk.) Ljung.

Amphiura tenera Lütken, Addit. ad Hist. Ophiur., pt. ii, p. 124, pl. iii, figs. 5*a*, 5*b*, 1857. Lyman, Illust. Catal. Mus. Comp. Zoöl., i, p. 123.

Amphipholis tenera Ljung., Ophiur. Viv., Kong. Akad., 1866, p. 312; op. cit., 1871, pp. 634, 645. Verrill, Bull. Labor. Nat. Hist. Univ. Iowa, v, p. 29, 1899 (description).

Shallow water on shell-sand, Bailey Bay, 1898. Charleston, S. C., to West Indies. Off Cuba, 100–200 fath.

Amphipholis Goesi Ljung.

Amphipholis Goesi Ljungman, Dr. Goes Oph., Kong. Acad., 1871, pp. 635, 648. Verrill, Expl. of Albatross in 1883, Annual Rep. U. S. Fish Com. for 1883, p. 549, 1885. Verrill, Bull. Labor. Nat. Hist. Univ. Iowa, v, p. 28, 1899 (description).

Amphiura Goesi Lyman, Voy. Challenger, Zoöl., v, pp. 125, 146, 1882.

Dredged in shallow water (20–30 feet), Bailey Bay, shell-sand, 1898. Off Cape Hatteras, 14 fath., to West Indies.

HOLOTHURIOIDEA.

[For a revision of this group, see Clark, Annals N. York Acad., xii, p. 117, 1899.]

Synapta viridis Pourt.

Synapta viridis Pourtales, Proc. Amer. Assoc. for Adv. of Science, 5th meeting, p. 14, 1851.

This small species was not uncommon among filamentous green algæ. It is very active. Most of the specimens were pale green to olive-green with white specks. The larger ones are about 30 to 36^{mm} in length, and are not mature. It was originally described from Biscayne Bay, Florida. Mr. Clark, op. cit., records three additional *Synaptæ* and *Chirodota rotifera* Pourt.

ECHINOIDEA.

The more common recorded species of echinoids are *Toxopneustes variegatus*, abundant on the shell-sand bottoms; *Hipponöe esculenta*, reefs and outer islands; *Diadema setosum; Echinometra subangularis; Mellita sexforis.*

XVII.—Additions to the Tunicata and Molluscoidea of the Bermudas. By A. E. Verrill.

Most of the published information concerning the Bermudian Tunicata is by Herdman in the Reports on the Zoölogy of the Challenger Exp., vol. vi. 1882 ; vol. xiv, 1886 ; and vol xxvii, p. 141. In these volumes several ascidians are described from Bermuda, viz:

Symplegma viride, vol. xiv, p. 144, pl. xviii, figs. 7–14.
Didemnum inerme, vol. xiv, p. 265, pl. xxxiv, figs. 6, 7.
Botrylloides nigrum, vol. xiv, p. 50, pl. ii, fig. 8 ; iii, figs. 19–21.
Ecteinascidia turbinata, vol. vi, p. 243, pl. xxxvi, figs. 1–6.
Clavellina oblonga, vol. vi, p. 246, pl. xxxv, figs. 6–10.
Ascidia nigra (Savig.) = *A. atra* (Les., 1817), vol. vi, p. 210.

All these species and many more were obtained by our party in 1898. The total number collected is about 25 species. These have, as yet, been but partially studied.

Among the additional genera are the following : *Diazona* (*D. picta*, sp. nov.) ; *Botryllus ; Leptoclinum*, several species ; *Distalium*, a new species forming pyriform colonies of a bluish gray or smoky brown tint when in formalin ; *Distoma ; Amorœcium ; Styela*, and others.

The most interesting species is that which I have named *Diazona picta*. It forms large compound clusters, usually attached to gorgonians, and often 6 inches or more in breadth and height. Each zoöid has the oral aperture surrounded by a carmine-red band and a stripe of the same color runs down one side, while the ground-color is translucent bluish or pinkish white, giving to the whole cluster an elegant appearance when living.

Additional Species.

Styela partita (Stimp.) Ver.

Cynthia partita Stimp., Proc. Boston Soc. Nat. Hist., iv, p. 231, 1852. Verrill, Amer. Jour. Sci., iii, p. 213, 1872. Rep. Invert. Anim. Vineyard Sd., p. 407 [701], pl. xxxiii, fig. 246, 1874.

Halocynthia partita Verrill, Proc. U. S. Nat. Mus. for 1879, p. 197.

Distinguished externally by the alternating stripes of red and white in the apertures.

Common on the under side of stones and dead corals and in crevices of the reefs. Mass. Bay to Florida and West Indies.

Styela canopoides Heller. Traust.

Similar to *S. partita* externally. Tunic salmon-color with very fine muscle-bands; oral siphon very short, scarcely prominent; atrial siphon short conical, not far back (distance ¼ whole length of tunic). Tentacles numerous, simple, very slender. Gonads in two groups on each side, pyriform, each group attached along the sides of a slender sinuous duct.

Halocynthia rubrilabia, sp. nov. Fig. 7.

Body rather large, swollen, oblong or oblong-ovate, usually longer than high, broadly attached, with the tubes wide apart, large, and moderately elongated in extension, nearly equal, or the oral a little longer.

Test thick, firm, more or less wrinkled, when large usually covered with extraneous matters through which the reddish color often shows but faintly.

Apertures similar, rather large, both 4-angled with 6–8 small lobules in each angle; when large roughly nodulose or warty.

Tunic very muscular, the muscular bands strong, forming a very distinct network; about 30 longitudinal bands on each side.

Branchial sac has six broad plications on each side; usually 4 or 5 large stigmata to each mesh. Dorsal lamina is represented by series of small languettes. Tentacles about 20, of several diverse sizes; the 12 largest ones are thick, tapered, acute, with 16 to 20 small, simple pinnæ on each side (fig. 7; *c*). Ciliated organ U-shaped, with both ends curved one way. Siphons red; apertures four-lobed, the sinuses rounded (fig. 7; *a*).

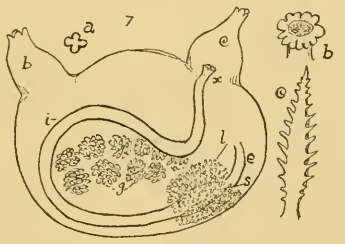

Figure 7.—*Halocynthia rubrilabia*, left side; *b*, branchial siphon; *c*, atrial siphon, ; *e*, œsophagus; *s*, stomach; *i*, intestine; *x*, anus; *l*, liver; *g*, gonads. *a*, Oral aperture. *b*, Anal papillæ. *c*, A tentacle, much enlarged.

The anus has a crenulated margin with about 12 unequal lobes, (fig. 7, *x*; *b*). Intestine forms a broad loop; liver is large, glomerate, greenish.

Gonads, in the adult, consist of 10–12 rather large glomerate lobules in two curved rows on each side, but so crowded that their serial arrangement is not very obvious; those of the left side lie mostly within the bend of the intestine. In younger examples they appear as separate, small, rounded, brown masses, arranged pretty regularly in two curved rows of 10–12 each, attached to the tunic.

Color of adult, reddish brown to pale red; the borders of the apertures bright red or rose-red, sometimes lined with a paler tint.

Greatest diameter, 35 to 50^{mm}; breadth, 20 to 25^{mm}; height, 25^{mm}; length of oral tube, 10 to 13^{mm}; diameter at end, 5 to 6^{mm}.

Common in shallow water, adhering to stones, dead shells, etc.

Halocynthia Riiseana (Traust.). Gen. *Cynthia* Savigny, 1816, *non* Fabr., 1808.

Cynthia Riiseana Traustedt, Vestindiske Ascidiæ simplices, Vidensk. Meddel. naturh. Foren. Kjobenhavn, 1882, p. 43, pl. v, fig. 13, pl. vi, fig. 19 (gill).

This species is allied to the last, but the tunic is flask-shaped and has longer and more divergent siphons, not so far apart, the anal one being dorsal and divaricate. The gill has 6 pairs of strong folds and 6–8 stigmata to a mesh instead of 4 or 5; tentacles 12, pinnate; anus bordered with longer papillæ; intestinal bend not so broad. Test in formalin is yellowish white; tunic pink.

One specimen, 1898. St. Thomas, W. I. (Traust.).

Microcosmus miniatus, sp. nov. Fig. 8.

Test orange-red, or bright red, rather thick and tough, leathery, ovate, somewhat flattened, attached obliquely by the base and one side, surface in the adults rudely wrinkled, often smoothish in the young; apertures far apart, on low verrucæ, which, in the adult, are covered with rude folds and irregular nodules, as contracted.

Figure 8.—*Microcosmus miniatus*, left side, partly diagramatic; *b*, branchial siphon; *c*, atrial siphon; *e*, œsophagus; *s*, stomach; *i*, intestine; *l*, liver; *g*, gonads; *d*, duct; *x*, anus. *a*, Oral aperture. *d*, Dorsal tubercle and aperture of ciliated organ. *g*, Group of gonads from right side.

Tunic red, rather muscular, the muscle-bands slender and forming a distinct network. Siphons not very long, divergent.

Tentacles large and strongly pinnate; about eight to ten larger ones alternate with others about one-half as large; the larger ones are bipinnate, the pinnæ being large and branched; there are also others of still smaller size. Ciliated organ (fig. 8; *d*) has the two lobes strongly spiral and incurved.

Branchial sac has 9 plications on each side, that next the endostyle being smaller than the rest. The dorsal lamina is a simple and plain band. Intestine forms a rather narrow bend, the two portions nearly or quite in contact for some distance. Liver large and bilobed.

The gonads, which are found on both sides (fig. 8, *g; g*), consist of about four double clusters of folicles arranged along each side of a curved tubular organ (*d*) attached to the tunic.

Length up to 30^{mm} ; breadth, 20–25^{mm}.

Shallow water, on the reefs and under stones.

Resembles *H. rubrilabia* externally, but can usually be distinguished by the redness of the entire test.

Polycarpa multiphiala, sp. nov.

Test brown, thick, leathery, tough, roughly wrinkled in contraction, ovate, depressed, attached by most of one side, partly covered with adherent shell-sand ; apertures near together, on large, short, thick, rudely wrinkled verrucæ. Tunic smooth, soft, rather thick, dark brown and nearly opaque, as preserved in formalin ; its muscular bands are fine and numerous, the net-work rather irregular. Siphons short and stout, enlarged distally; apertures with four large lobes.

Tentacles many, simple, slender, subequal, curved inward, pigmented on inside; 40 were counted in the type. Branchial sac has 4 broad plications on each side ; 6–12 stigmata to a mesh (usually 8 or 9). Gonads attached to tunic, numerous, small, flask-shaped with two small apertures at the free end. Intestinal bend small, simple ; stomach enlarged.

Length, 45^{mm} ; breadth, 30^{mm}.

On the reefs, not common.

Allied to *P. Mayeri* Traust., of the Gulf of Naples.

Diazona picta, sp. nov.

Plate LXX. Figure 8.

Forms large gelatinous colonies, consisting of a massive main stem from which arise more or less numerous lobes, each lobe often containing 12 to 20 zoöids, which, in expansion, are much exsert above the common mass, the free portion being slender and three or four times as high as broad. Apertures, when expanded, on short terminal tubes, the oral one larger and higher than the atrial.

General color usually translucent pinkish white ; oral aperture surrounded by a band of bright carmine-red, edged on both sides with flake-white ; a stripe of the same carmine color extends from the oral band down the ventral side of each zoöid.

Height of larger colonies 125 to 160^{mm}; breadth about the same; height of free part of zoöids in life, 15 to 20^{mm}; their diameter 5 to 6^{mm}; diameter of oral tube about 2^{mm}.

Harrington Sound and Castle Harbor, just below low-tide, usually attached to gorgoniæ or bryozoa.

MOLLUSCOIDEA.

BRACHIOPODA.

No species of this group, so far as I know, has hitherto been recorded from the Bermudas.

By examining carefully the under side of unbleached specimens of the delicate, foliaceous coral, *Mycedium fragile*, I found a number of small specimens, mostly immature, of a reddish species of *Cistella*. A few were also found on the under side of *Isophyllia dipsacea*, and on the base of *Oculina*. Most of these, if not all, were taken in Harrington Sound, just below low-tide mark.

Cistella cistellula (Searles Wood).

Plate LXX. Figure 7.

Professor Chas. E. Beecher, who has studied these specimens, furnishes the following note :—

"The Bermuda variety agrees in form and structure with *C. cistellula* from Great Britain. It differs principally in its more uniform outline and in color. Typical examples of *C. cistellula* are of a yellowish brown hue, while the Bermuda shells are nearly white with four not clearly defined, broad, radiating bands of red."

BRYOZOA or POLYZOA.

This group is much less abundant in the Bermudas* than on the New England coast or in the Florida and West Indian seas. Only about 20 species, mostly well known West Indian forms, were obtained by the Yale party. Most of these are incrusting species of *Escharidæ*, found on the bases or dead parts of corals.

A curious large form (?*Schizoporella Isabelliana*, fig. 5), commencing as an encrusting species, becomes massive by one layer of

*Several Bermuda species have been recorded in various works, but more particularly by Busk in the Challenger Reports, vols. x and xvii. Our collection has not been sufficiently studied to warrant the insertion of a list of species new to the fauna, at this time.

zoœcia growing over another, and finally, by surrounding the tubes of serpulæ or other objects and growing beyond them, forms large groups, often 6 inches high, of thin-edged tubular branches, having the thin expanded tips, in life, light pink or orange-red. Its aper-

Figure 5.—*Schizoporella Isabelliana* ? ; group of cells ; much enlarged.

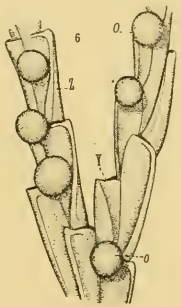

Figure 6.—*Bugula* (or *Acamarchis*) *neritina* ; x, zoœia ; y, aperture ; o, o, oœcia.

tures have a rounded proximal emargination. The acute pedicellariæ are at the sides of the aperture. When dried this species becomes dark purplish brown or blackish. *Hippothoa*, or *Schizoporella, spongites* is also common in foliaceous growths on corals. Other common forms are *Amathia lendigera*, a *Lichenopora* like *L. radians*, and *Crisia denticulata.*

One large, brown, thickly-branching species of *Bugula* (*B. neretina*, fig. 6) is common. It grows four or five inches high.

A much more delicate, white *Bugula* consists of divergent fan-shaped branches attached to the alternate sides and to the tip of slender jointed stems, sometimes having alternately a long joint and a very short joint, but more frequently the short joint is lacking and the ends of the long joints are swollen, as in *Stirparia.*

There are usually 2 or 3 annulations at the base of each main branch, and these arise just below the internodes. Many of the cells have a slender distal vibraculum, or sometimes two.

It should, doubtless, form the type of a new genus or subgenus (*Caulibugula*), intermediate between *Bugula* and *Bicellaria*, on account of its articulated spines or vibracula, and related to *Stirparia* by its jointed stem. It may be named *Bugula* (*Caulibugula*) *armata.* Its zoœcia are oblong and biserial, alternate ; the pedicellariæ are on short pedicels, large, lateral, not numerous.

A small intricately branched cellularian, *Scrupocellaria cervicornis* (Smitt, as *Cellularia* from Florida) with antler-shaped markings on the fornix or shield, long vibracula, and 4 to 6 distal marginal spines, is common.

Biflustra dentata Busk is common on Sargassum, found on the beaches. *Steganoporella elegans* (Edw.) Smitt is common on dead corals, both in encrusting and in free foliaceous forms.

The most interesting species was a curious species of the family *Pedicellinidæ* which forms large groups on the under side of stones, or on ascidians, sponges, etc., at low-tide mark. When disturbed it bends its stalks over to one side with a rather sudden jerk, which is sure to attract the attention of the collector when the clusters are large. This motion is effected by means of strong muscles lodged in a cylindrical dilation of the base of the stalk. It belongs to the genus *Barentsia* of Hincks or *Ascopodaria** Busk.

PEDICELLINIDÆ.

Barentsia timida, sp. nov.

PLATE LXX. FIGURE 4.

A large species forming extensive groups, connected by slender round stolons, that usually branch at right angles, from under the base of each zoöid.

Stem not very long, varying in length from 3 to 5 times as long as the height of the body, its basal portion, for a length equal to about the height of the body, much enlarged, cylindrical, tapering abruptly to the slender portion, and containing a large deflector muscle; above this the slender stem gradually increases in size distally; one or two annulations at the base of the body; the enlarged basal portion is covered with numerous fine annulations; the slender part appears punctate, owing to small tubular extensions of the lighter yellow inner layer, but these usually do not cause any elevations of the exterior.

Body cup-shaped or wide campanulate. Tentacles numerous, long, slender, curled in contraction.

Height of stems, 4-6^{mm}; of basal enlargement, 0.75 to 0.90^{mm}; its diameter, about 0.3^{mm}; height of body, 1^{mm}; its diameter, 0.8 to 1^{mm}.

On under side of stones, on sponges, corallines, ascidians, etc., at low-tide, common.

This species is closely allied to *B. discreta* (Busk), Voy. Challenger, xvii, p. 44, pl. x, figs. 6–12. The latter has, however, a shorter and more strongly annulated basal cylinder and also several annulations of the stem below the base of the cup; its tentacles are only 12 in number.

* Mr. Busk (op. cit., p. 41) admits that *Barentsia* has priority of publication, although he had himself previously distinguished the genus in MSS.

XVIII.—Additions to the Turbellaria, Nemertina, and Annelida of the Bermudas, with Revisions of some New England Genera and Species. By A. E. Verrill.

Very little has hitherto been published concerning the Turbellaria and Nemertina of the Bermudian fauna.* Both these groups seem to be sparingly represented there, though some of the species are of special interest.

Particular efforts were made by our party to make good collections of these groups and of the Annelida. Yet of the two former groups we found only three planarians and four or five nemerteans. The nemerteans were all of rather small size and inconspicuous coloration, contrary to what is usually the case in the warmer seas.

TURBELLARIA; DENDROCŒLA.

Leptoplana lactoalba, sp. nov.

Body, when extended in life, long-lanceolate or narrow-oblong, very flat, with thin undulated edges. Ocelli rather numerous,

Figure 9.—*Leptoplana lactoalba.* ×1½.

arranged in two parallel series, each series having a rounded cluster near the posterior end and about two separated larger ocelli in line behind each cluster.

Color, translucent milk-white.

Length, in life, 30–50^{mm}; width, 10–12^{mm}.

Under stones and corals on the reefs, 1898.

Similar to *Leptoplana pallida* of the Gulf of Naples.

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* A small terrestrial nemertean (*Tetrastemma agricola* W. Suhm) was discovered at Bermuda, by the naturalists of the Challenger. It occurs in brackish moist localities under stones, etc. (See Mosley, Notes by a Naturalist, p. 26.)

Pseudoceros superbus Lang.

Lang, Die Polycladen, Fauna und Flora des Golfes von Neapel, p. 540, pl. v, fig. 5; pl. xxi, figs. 2, 14; pl. xxii, figs. 1, 2, 3, 6, pl. xxx, fig. 18.

PLATE LXX. FIGURE 5.

Three specimens of this large and handsome species were obtained. We found it difficult to preserve well by any of the ordinary methods, either in alcohol or formalin. It is soft, thin, and very mutable in form.

Its color, in life, is a very rich, dark, purplish black or very dark maroon, with a velvety appearance, bordered all around with a narrow marginal band of bright orange, edged with light orange, while the extreme edge is purplish brown; under side brownish purple.

Length, in life, 50 to 60^{mm}; breadth, 25 to 30^{mm}.

Under stones at and just below low-tide, usually associated with a dark botrylloid compound ascidian or with a dark purplish sponge, with both of which it corresponds closely in color.

This is one of the few species of Bermudian marine invertebrates which appear to be certainly identical with Mediterranean species, though many are closely related. Among the nemerteans there is another case of this same kind (*Tæniosoma curtum* Hubr.).

Pseudoceros pardalis, sp. nov.

PLATE LXX. FIGURES 6, 6*a*.

A large, broad species, covered with yellow spots.

Body, as preserved, broadly elliptical or oblong-ovate, subtruncate anteriorly, with thin undulated margins. Ocelli numerous.

Color, in alcohol, brownish black, covered with numerous round, pale yellow spots (probably bright yellow in life). Length, 60^{mm}; breadth, 40^{mm}.

The only specimen of this fine species was collected many years ago by Dr. C. Hartt Merriam and presented by him to the Museum of Yale University.

NEMERTINA.

The most interesting nemertean, as well as the most common, appears to be identical with a Mediterranean species of wide distribution. Mr. W. R. Coe, who has studied the Naples nemerteans in the Biological Station, made sections of my Bermudian specimens for comparison. He has given me the following synonymy and memoranda concerning this species:—

Tæniosoma curtum (Hubrecht) Coe.

Polia curta Hubrecht, Genera of European Nemerteans critically revised, Notes Leyden Museum, 1879.

Eupolia marmorata Bürger, Unters. ueber Anat. u. Histol. der Nemertinen, Zeitschr. wiss. Zoöl., vol. 1, 1890.

Eupolia curta Joubin, Les Némertiens, Faune Française, Paris, 1894. Bürger, Nemertinen, Fauna und Flora des Golfes von Neapel, Monogr. 22, 1895.

Plate LXX. Figure 3.

"The specimens obtained in Bermuda belong to the more slender variety of the species, and show numerous sharply-marked, but interrupted, longitudinal lines. Both in their external appearance and internal organization these specimens exhibit a close resemblance to *Tæniosoma delineatum* (= *Polia delineata* Delle Chiaje,* = *Eupolia delineata* Hubrecht†), and in many respects are intermediate between the two species. The Bermudian form agrees in detail with the specimen collected at Mauritius and drawn by Möebius.‡ The species has a wide range of distribution. It is common in the Mediterranean, and has been recorded, also, from Mauritius, Chili, Samoa, Fiji Islands, and other localities in the tropical and subtropical seas of both hemispheres.

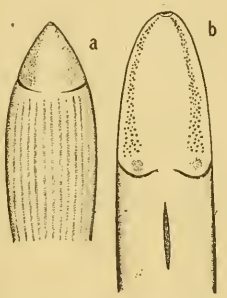

Figure 10.–*Tæniosoma curtum; a*, dorsal; *b*, ventral views of the head. ×4.

T. delineatum has an even greater range of distribution than has *T. curtum*, and is commonly found associated with it. From my experience with Naples forms I am somewhat doubtful whether this is specifically distinct from *Tæniosoma curtum*."§

When fully extended in life our larger specimens were 250 to 300^{mm} long; they were quite slender and flattened, about 2 to 3^{mm} broad, but changeable; the head is usually a little broader than the body, and subacute. In contraction the body is nearly round. General tint, to the naked eye, is light smoky brown, yellowish brown, or chocolate-brown, due to numerous narrow alternating

* Memorie sulla storia e notomia degli animali senza vertebre del regno di Napoli, Naples, 1823–28.

† Voyage of the Challenger, Nemertea, Zoöl., vol. xix, 1887.

‡ Bürger, Beitr. zur Anat., etc., der Nemertinen, Zeits. wiss. Zoöl., lxi, 1895.

§ The generic name *Tæniosoma* Stimpson, 1854, Proc. Philad. Acad. Sci., ix, has evident priority over all other names proposed for this genus.

stripes of dark chocolate-brown and grayish or yellowish white. About 100 minute ocelli in each lateral group.

Common in shell-sand at low-tide and also in cavities in dead corals.

Lineus albocinctus, sp. nov.

Plate LXX. Figures 1, 1*a*, 1*b*.

Body not very long, slender, tapered posteriorly, a little flattened; head usually a little wider than body and more depressed. Ocelli small, about 4 or 5 in a single series on each side of the head. Lateral fossæ large and long.

Color dark smoky-brown or nearly black, crossed by about 20 white rings, which become like narrow white lines in contraction; neck usually with a wider white band; head with white edges and a median white dorsal spot. Under side whitish.

Length, in extension, 35 to 50^{mm}; diameter, about 1 to 1.5^{mm}.

Low-tide, among corallines.

Lineus albonasus, sp. nov.

Plate LXX. Figure 2.

Body small, very slender, tapering posteriorly; head not enlarged. Ocelli usually two on each side, in the white patch.

Color red, usually brownish red anteriorly, and becomes light cherry-red posteriorly; front of head clear white above.

Length, in extension, about 35^{mm}; diameter 1^{mm} or less.

Bailey Bay, at low-tide.

Another nemertean, 100 to 150^{mm} long and about 3^{mm} in diameter, in extension, was found at low-tide in tenacious tubes coated with shell-sand. It is light orange-yellow anteriorly, becoming pale ochre-yellow posteriorly. Proboscis long and slender. It is probably a *Lineus*, but has not been carefully studied.

ANNELIDA.

The annelids are numerous at Bermuda, but our collection has not yet been fully studied. It includes over 110 species. A list of Bermudian annelids was published by Prof. H. E. Webster* in

* The Annelida from Bermuda collected by Mr. G. Brown Goode, Bulletin U. S. Nat. Mus., No. 25, p. 307, pl. vii–xii, 1884.

1884, based on the collection made by Mr. G. Brown Goode in 1872. This list included 26 species, of which 13 were described as new.

Five species, viz: *Podarke obscura* Ver.; *Arabella opalina* Ver., *Arenicola cristata* Stimp.; *Enoplobranchus sanguineus* Ver.; *Hydroides dianthus* Ver. are found, also, on the southern New England coast, but probably range southward to the West Indies. The balance are known West Indian species.

M'Intosh, in Report Voy. Challenger, Annelida, vol. xii, 1885, records 13 littoral species of Bermuda annelids, some of which are identical with those of Webster's list.

One of the larger and more conspicuous forms is *Protulides elegans* W., which projects from its tough tubes large and elegantly formed branchial plumes, as brilliant and varied in colors as carnations. It is common on the reefs, its tubes being contained in dead corals. It is also found on the coast of North Carolina.

Another large species is *Terebella magnifica* W., which lives buried in shell-sand at low-tide. In life its large flaccid body, which is pale flesh-color or nearly white, is often 12 to 16 inches long and about half an inch in diameter, while its numerous white tentacular cirri can be extended more than a foot in every direction. This belongs to *Polymnia* Malmg. or *Eupolymnia* Ver.

The *Hermodice carunculata* Kinb. is a large, stout species, densely covered with sharp, white calcareous setæ, with red gills between them. It is very common under stones at low-tide.

Cirratulus grandis Verrill, a large yellowish green or olive-green worm, with numerous long orange-red cirri, is common at low-tide in sand, especially in stony places. It agrees perfectly with New England specimens. It is not in Webster's list.

In our collection there are three species of Phyllodocidæ and more than twenty-five of Syllidæ, including ten species of *Syllis*. These families are not included in Webster's list.

Polynoë pustulata M'Int. = *Polynoë granulata* Ehlers = *Halosydna leucohyba* Web., *non* Schmarda, a large scaly species, was common, living as a commensal in the tubes of a large *Eunice*, in dead corals.

Miss K. J. Bush has identified the following species in our collection that are new to the fauna:

Nereis articulata Ehl.
Nereis Antillensis M'Int.
Trypanosyllis vittigera Ehl.
Eunice violaceomaculata Ehl.
Marphysa Goodsiri ? M'Int.
Lumbrinereis Floridana Ehl.
Branchiomma lobiferum Ehl.
Eupomatus uncinatus (Phil.) Ehl.

Additional unrecorded species occurred in the following genera:—

Nereis.
Leodice or *Eunice*, 7 sp.
Marphysa, 2 sp.
Arabella.
Cirratulus.
Aricia.
Anthostoma or *Scoloplos.*
Sabella.

The following genera, hitherto unrecorded from the Bermudas, are represented in our collection by undetermined or new species:—

Chrysopetalum.
Sthenelais.
Eulalia.
Phyllodoce.
Eteone.
Autolytus, 2 sp.
Syllis, 10 sp.
Haplosyllis, 2 sp.
Eusyllis, 2 sp.
Desmosyllis, g. nov.
Trypanosyllis, 3 sp.
Hemisyllis, g. nov.
Opisthosyllis.
Odontosyllis, 2 sp.
Branchiosyllis.
Grubeosyllis, n. nov. 2 sp.
Lysidice.
Paramarphysa.
Heteromarphysa, g. nov.
Nematonereis.
Lumbrinereis, 2 sp.
Staurocephalus or *Staurinereis*, n. nov. 2 sp.
Cirrhinereis or *Cirronereis.*
Heterocirrus.
Capitella
Notomastus.
Clymene or *Euclymene*, n. nov.
Axiothea or *Axiothella*, n. nov.
Polydora.
Pectinaria.
Loimia.
Eugrymæa, g. nov.
Protothelepus, g. nov.
Nicolea.
Polymniella, g. nov.
Polycirrus, 3 sp.
Protula, 2 sp.
Vermilia, 2 sp.
Filigrana.
Spirorbis, 2 sp.

The following are some of the new species* obtained, especially of the Syllidæ and Eunicidæ.

Phyllodoce Bermudæ, sp. nov.

A small, slender species, with cordate-lanceolate posterior branchiæ and large caudal cirri.

Head small, rounded, both in front and behind. The front a little more produced. Antennæ about equal, lower a little shorter; upper ones as long as head, fusiform with acuminate tips; tentacular cirri similar in form, but longer. Eyes large, round, black, posteriorly placed. Inferior branchial lobes, on the anterior segments, oblong-ovate, $1\frac{1}{2}$ times as long as broad, with round blunt tips; farther back they gradually increase in size and length, those about the middle

* The illustrations of these species could not be finished in time for publication in this article. They will be published in vol. xi of these Transactions in connection with the full report on the Annelida.

being twice as long as broad. Upper branchiæ are preserved only on the posterior third of the body; the most anterior seen are cordate-lanceolate, one-third longer than broad, with blunt tips; farther back they become narrower lanceolate. Caudal cirri large, dark colored, oblong-ovate, obtuse, 4 times as long as broad. Setæ are long and very slender, the blades rather long, straight, very acute.

The color in formalin is reddish brown (in life probably green); the branchial appendages and caudal cirri are more deeply pigmented than other parts, and nearly opaque; a transverse fusiform lighter spot exists between the segments, bounded by narrow, curved, whitish lines; there is a dark spot at the dorsal base of the parapodia, surrounded by a pale zone.

Length, as preserved, about 14^{mm}; diameter 1^{mm}, in life much longer.

Eulalia megalops, sp. nov.

A long and slender, dark green species with very large eyes.

Body wider in the middle, tapering gradually to both ends. Head ovate, obtuse in front, longer than broad. Eyes very large, black; four frontal antennæ long, slender, whitish; odd tentacle similar in size; 4 pairs of long, slender, tapered tentacular cirri, the dorsal pairs longer, in life six times as long as head. Branchial lobes of parapodia falcate, long, narrow, acute, curved upward, 1½ to 2 times as long as breadth of body.

Color, in life, mostly dark olive-green; branchiæ light green; anterior segments with a whitish transverse marginal line and a pale median patch. Length, in life, 90^{mm}; breadth, 1.5^{mm}.

Bailey Bay, in dead corals.

Syllis Savigny. (Including *Typosyllis* and *Ehlersia*.*)

The genus *Syllis* is here taken to include those species having minutely bidentate tips to the terminal blades of the compound setæ, as well as those in which the tips are acute. In some species both forms occur on the same individual and in many cases the bidentation is so slight as to be visible only under a high power objective (e. g. No. 6, Zeiss or Leitz, or ⅛ inch American), so that it seems useless to make this a generic character. *Eusyllis* Malmgren was separated mainly on this account from *Syllis*, but the type species, *E. Blomstrandi* M., also has the dorsal cirri nearly smooth or with-

* For a synoptical table of the genera and subgenera of Syllidæ here described see p. 632.

out evident articulation or beading, while in true *Syllis* they are very distinctly beaded or articulated. This was made the principal character of *Eusyllis* by McIntosh. Langerhans restricted it to species having the edge of the œsophagus denticulated, and in that sense it is used by me. All the Bermuda Syllidæ studied by me, except *Odontosyllis*, *Autolytus*, and *Grubeosyllis*, have distinctly and usually strongly articulated cirri.

In most of the following species the blades are decidedly longer on the upper than on the lower setæ, and they are decidedly shorter on the posterior segments than on the anterior, so that no very close descriptions nor measurements can be briefly given that would be useful. Nor are the differences so marked as to be very useful for the recognition of related species, even when figured, owing to the variations of each. The forms of the palpi, antennæ, cirri, œsophagus, and stomach afford better characters, though these are all able to vary considerably by contraction.

In our species of *Syllis* the œsophagus (or chitinous pharynx) has a solitary, conical, median tooth, and usually a smooth anterior margin, becoming revolute when extruded from the mouth, but in a few the margin is minutely crenulate, or it may be ill defined, passing gradually into the soft part.

More than one species of *Syllis* was observed, in life, in the process of producing one or more free sexual zoöids by the alteration and breaking away of a certain number of posterior segments, as in *Autolytus*, and some were preserved with the fully formed zoöids attached. These agree with the genus *Tetraglene*. They have large eyes, with a lens, but lack antennæ and palpi. They have fascicles of long capillary setæ, in addition to the compound setæ, and long beaded cirri. Several specimens of *Tetraglene* were also taken in the surface towing-net, in the evening, about the last of May, associated with the allied form of sexual zoöids known as *Chætosyllis*.

But in related species of *Syllis* (*S. corallicola*, *S. catenula*, *T. fertilis*) masses of ripe eggs were found along the posterior half of the body, without any alteration of the segments, setæ, or cirri. The species of *Syllis* seem, therefore, to differ widely in their life histories.

Many of the following species of Syllidæ were obtained by breaking up dead and decayed masses of corals, and placing them in dishes of water for the annelids to crawl out. Others were obtained by placing masses of living corallines and sponges in the dishes, especially at night, for the same purpose.

Syllis (Typosyllis) corallicola, sp. nov.

A large species with long, strongly beaded antennæ and cirri, and with a large, rather short, dark brown, chitinous œsophagus armed with a single tooth near the emarginate edge.

Head large, about one-third broader than long (1: 1.33 to 1: 1.50 in contraction), frontal margin broadly rounded and slightly three-lobed, the median lobe only slightly prominent, sides strongly convex, narrowing backward, posterior margin with a wide shallow emargination. Eyes conspicuous, with lens, but not very large, the anterior distinctly larger and farther apart, those of the same side pretty near together. Palpi large and broad, separate to base; when extended the free part is as long as the head or longer, ovate-lanceolate, slightly incurved on inside, obtuse at the end. Odd antenna or tentacle long and tapered, about 5 times as long as the head, its free portion $3\frac{1}{2}$ times as long as that of the palpi, strongly beaded, the annuli about 40, short and not very separate proximally, but becoming longer and very distinctly constricted distally. Antennæ about $\frac{1}{3}$ shorter than the tentacle, and more slender, beading similar, the annuli broader than long. Dorsal tentacular cirri much like the tentacle, but $\frac{1}{3}$ longer; ventral one smaller and nearly $\frac{1}{2}$ shorter. Anterior dorsal cirri are also mostly long like the tentacular cirri, but farther back part of them, alternating irregularly, become shorter; the longer ones are 2 to 3 times as long as the tentacle and equal to twice the diameter of the body, while the shorter ones are equal to about $\frac{2}{3}$ its diameter.

The setæ are slender and long, the upper ones with rather long, narrow, nearly straight, lanceolate blades, 6 or 8 times as long as wide, with minutely bidentate tips; the lower and posterior ones have wider, bidentate blades, often only 2 or 3 times as long as broad. Anteriorly 3 or 4 spiniform acicula occur in each fascicle; 1 or 2 posteriorly.

The œsophagus (or chitinous proboscis) is stout, moderately long, occupying 10–12 segments, often wrinkled or crumpled in contracted specimens, dark brown, its anterior edge not denticulated, but with a ventral emargination; the median tooth is rather large and a little back from the edge. The stomach is long, occupying 14–17 segments, in preserved specimens about $\frac{1}{3}$ longer than the œsophagus and decidedly stouter, a little wider in the middle, covered with dense rows of dark rounded granules or glands.

Color, in formalin, yellowish white; the annuli of the cirri have groups of pale greenish pigment cells.

Length up to 1.5 inches or more (or 40^{mm};) diameter, 2–3^{mm}.

Var. lineolata, nov.

This variety occurs with the preceding form, from which it differs chiefly in color. The cirri and antennæ are equally long, and the setæ have the same forms. In formalin each anterior segment is crossed close to the anterior edge by a narrow brown line; another similar transverse brown line runs across the middle of the segments, but does not reach the sides; behind the middle of the body these lines gradually fade out. In some specimens they are rather faint even anteriorly. The color in life was not noted. Both varieties were common in the cavities of dead corals, from the reefs; also in corallines.

Syllis grandigularis, sp. nov.

This closely agrees in size and appearance and in its setæ, with *S. corallicola*. It differs in having a larger and broader head, widest in front of the eyes, which are black and in a trapeze, and especially in the very large size of the œsophagus and stomach, and their structure. The œsophagus is nearly as long and almost as thick as the stomach, and nearly fills the anterior part of the body; its margin is nearly even and entire, but appears to be minutely crenulated when extruded, and the median tooth is very large, blunt-conical, and projects one-third of its length beyond the margin of the extruded proboscis. The stomach is elongated, tapering a little toward both ends; it occupies 8 segments; its surface is covered with numerous close, confused and irregular rows of cells,* but they do not form regular, rounded groups, as in most other species.

The antennæ and cirri are all long and slender,—more slender than in *S. corallicola* and *S. catenula*,—and composed of numerous round strongly pigmented beads, about as long as broad. The posterior setæ are longer than the anterior with strongly incurved acute blades on the lower ones. Allied to *S. annularis*, also.

Length, in formalin, 18^{mm}.

Syllis (Typosyllis) catenula, sp. nov.

A smaller and more slender species than the preceding with rather shorter cirri, long palpi, and a rather longer and more cylindrical œsophagus, armed with a small tooth close to the entire and even margin, usually with linked markings on back, often causing three rows of pale spots. Head about one-half wider than long (ratio

*According to some observers these are radial muscular cells, not glandular.

1:1.45), the front edge usually slightly and broadly three-lobed, sometimes rounded; sides evenly rounded; posterior strongly emarginate. Eyes rather small, the pairs far apart, those of each side close together, the anterior larger and more lateral, with lens. Palpi large and long, divergent, lanceolate, somewhat falcate, with a broad base, blunt end and incurved inner margin; the free part usually projects $\frac{1}{4}$ more than the length of the head. Tentacle tapered, moderately long, nearly three times as long as head, about $\frac{1}{3}$ of its length projects beyond the palpi, strongly and elegantly beaded, with 20–22 annuli, these are 2 to $2\frac{1}{2}$ times as broad as long distally, each with pigmented cells. Antennæ similar, with the same beading, $\frac{1}{4}$ to $\frac{1}{3}$ shorter and smaller, projecting only a little beyond the extended palpi. Dorsal tentacular cirri similar to tentacle but about $\frac{1}{3}$ longer, with 28–30 annuli; lower ones about $\frac{1}{2}$ as long. First dorsal cirri still longer, about $1\frac{1}{2}$ times as long as the tentacle, with 30 or more annuli. Several others on the anterior segments are nearly as long, but alternate irregularly with much shorter ones, $\frac{1}{2}$ to $\frac{2}{3}$ as long, all becoming rather shorter posteriorly; the longer ones are about twice as long as the diameter of the body. Caudal cirri long and slender, beaded like the dorsal cirri and equally long, but more slender. Setæ slender, the upper ones with nearly straight, narrow lanceolate blades, 4 or 5 times as long as wide, with slightly bidentate incurved tips, sometimes entire; the ventral and most posterior setæ have the blades much shorter. Acicula usually 2–4, spiniform.

Œsophagus rather long and slender, occupying 10–12 segments, in extension $1\frac{1}{4}$ times the length of the stomach, but it is sometimes made shorter and wrinkled in contracted specimens, so that it may be scarcely longer than the stomach. When protruded from the mouth the aperture is flaring with the margin even, entire, and often revolute; the tooth is small, acute, near the edge and sometimes projects beyond it when everted. The soft membranous proboscis when everted shows about 10 rather broad obtuse denticles or lobes, the 6 dorsal ones larger. Stomach long, cylindrical, usually occupying 6 to 8 segments, usually shorter than the œsophagus and distinctly larger, covered with close rows of rounded glandules. Color, in formalin, yellowish white, each segment anteriorly marked dorsally with two curved transverse lines of brown, which converge and blend into a spot on the middle of each segment, and also unite at the sides, so as to enclose, on each side, an elliptical pale spot, and leave a similar spot between the segments along the middle of the back; thus there are three alternating rows of pale spots along the back, but these

fade out posteriorly and are often indistinct anteriorly. Color, in life, was not noted. One ♀ was found filled with eggs.

Length of preserved specimens usually 20–25^{mm}; diameter, .75 to 1^{mm}.

Common among corallines and in dead corals.

Syllis jugularis, sp. nov.

This species is closely related to *S. catenula*, with which it agrees very nearly in its cirri and setæ. It is somewhat smaller and more slender. The most obvious difference is found in the œsophagus, which is much longer and more slender than that of the latter. It is straight and rather narrow, nearly cylindrical, with a basal swelling and an even, entire, expanded or flaring margin. Its tooth is very small, conic, close to the edge, or projecting a little beyond it. When extruded its base is at the 14th segment and its margin projects much beyond the head. The stomach is much shorter (about one-half as long), and occupies about 7 segments. It is cylindrical and has numerous regular rows of rounded groups of cells.

Length, 12^{mm}.

Syllis (Typosyllis) diplomorpha, sp. nov.

A large elongated species which produces *Tetraglene*-zoöids by posterior fission. Proboscis pale colored, short, stout, shorter than stomach.

Head large, nearly as long as wide, narrowed behind middle, three-lobed anteriorly, broadly and strongly emarginate posteriorly (ratio in type 1:1.15). Eyes black, large, the anterior at least twice as large as the others and considerably farther apart, but only a little more in advance, the distance between the two about equal to the diameter of the anterior eyes; posterior eyes just behind bases of antennæ. Palpi divergent, large and broad, about as long as the head, lanceolate, obtuse, incurved on the inside. Tentacle long, 3½ times as long as the head, regularly beaded. Antennæ similar, but shorter, about 2½ times the length of the head; upper tentacular cirri about equal to the tentacle; lower equal to the antennæ. First and fourth dorsal cirri long, about ⅓ longer than the upper tentacular cirri; 3d and 4th are somewhat shorter, about equal to the tentacle; farther back the dorsal cirri are shorter, more slender and tapered, and unequal, the longer ones in the middle of the body are about equal to ⅔ the diameter of the corresponding segments; the shorter ones about half as long.

Setæ are long and abundant; the upper anterior ones have narrow lanceolate blades, 3 to 4 times as long as broad, with slightly bidentate tips; the lower ones are only about 2 times as long as broad, with incurved tips.

The œsophagus is stout and rather short, occupying 7 segments, cylindrical, about $\frac{1}{3}$ shorter than stomach and nearly as thick; it is unusually translucent, lacks the brown chitinous color seen in most species; its tooth is near the margin, which is not well defined, but seems to be entire. The stomach is long and thick, cylindrical, and occupies 9 segments; it is crossed by numerous crowded rows of rounded granules.

Color of type, in formalin, pale greenish brown, each anterior segment crossed by a pale narrow sutural line and sometimes by a darker brown middle line; posterior half of the body has a row of squarish spots along each side at the bases of the parapodia. Length, 30^{mm}; diameter, 1.5^{mm}.

The posterior end, in the type, is changed into a *Tetraglene*-zoöid, back of the 110th setigerous segment. The new head has four very large and prominent black eyes with lens, but lacks all other appendages, the eyes are in contact on each side. There is no buccal segment, the first segment is very short and has setæ. All the 20 segments bear fascicles of long, slender capillary setæ, longer than the breadth of the body, and a smaller number of compound setæ. The dorsal cirri have been lost.

The parapodia are large and prominent, as long as half the breadth of the segments.

Syllis (Tetraglene), sp.

In a small collection of plankton, taken in the latter part of May, there are several specimens of a *Tetraglene* somewhat similar to the above, but evidently a distinct species.

The head is much shorter and smaller, with very much smaller, separated, light brown eyes. The body itself is larger and much stouter, with 24 crowded, broad segments and short, rounded parapodia. The dorsal cirri equal about $\frac{1}{4}$ the breadth of the segments, and are regularly beaded and tapered. The caudal cirri are not tapered, as long as the dorsal cirri, and strongly beaded with about 10 annuli, the distal beads are nearly round. Large fascicles of slender compound setæ are present on all the segments, with short terminal blades, $1\frac{1}{2}$ to 2 times as long as broad, part of them very minutely bidentate at tip. No capillary setæ are present on either specimen. A row of rather dark, round spots runs along each side, a spot being at the base of each parapodium.

Syllis (Chætosyllis), sp.

Several specimens of sexual zoöids with two antennæ, but otherwise like *Tetraglene*, were taken at the surface. They probably belong to some species of *Syllis*.

Syllis (Typosyllis) annularis, sp. nov.

A small species with long slender antennæ and dorsal cirri, banded with dark green, and with long fascicles of setæ, the posterior ones longer and stouter with short, strongly incurved, acute blades; œsophagus short, wide, brown, with a long acute tooth.

Head large, broader than long, widest at the front, opposite anterior eyes, narrowed backward; front margin broadly rounded; posterior margin broadly emarginate. Eyes not very large, pale brown, the anterior a little larger and separated from the posterior by a space equal to their diameter; a minute brown pigment speck at the base of each palpus may represent the third pair of eyes. Palpi large with broad swollen bases, rather longer than the head, abruptly narrowed on inside, at about the proximal third, blunt at tip.

Tentacle stout, a little tapered, about $\frac{1}{2}$ longer than the palpi, strongly annulated, with about 20 annuli; the distal ones longer than broad. Antennæ similar, a little shorter, the ends reaching to within two or three distal annuli of the tentacle tip. Upper tentacular cirri rather longer than tentacle, but of the same thickness; lower one somewhat shorter. First dorsal cirrus larger and about $\frac{1}{3}$ longer than tentacle, of about 38 annuli, the distal half a little stouter than the proximal; most of the cirri on the first eight segments are similar to those of the first, or even longer, or about $\frac{1}{3}$ longer than the breadth of the body; some still longer and more slender occur even back of the middle, composed of 48 to 52 annuli, with others about $\frac{2}{3}$ as long, of 38 annuli, but the shorter ones usually exceed the breadth of the body.

Setæ of anterior segments are in large fascicles of 5 to 10, all compound, but with about 3 stouter acicula that project but little or not at all; the upper setæ have narrow lanceolate, slightly curved blades, 6 to 7 times as long as wide, with minutely bidentate tips; the lower ones have wider and shorter blades, length to breadth about 3 or 4:1, with strongly incurved, acute, claw-like tips; posteriorly most of the setæ are longer with stouter stems, but the lower ones are shorter; there are about 6–8 in a fascicle, with two or three stouter spiniform acicula, projecting but little; the upper setæ

have stout curved blades, about 3 or 4 times as long as broad, with strongly incurved acute tips; the lower ones have shorter, much curved, acute, claw-like blades, 2 or 3 times as long as broad.

The œsophagus is brown, large, stout, nearly cylindrical, a little contracted at each end, about $\frac{1}{3}$ shorter than the stomach and $\frac{2}{3}$ as broad, occupying 9 segments; anterior margin is entire or feebly crenulate, a little emarginate dorsally; the median tooth is large, long, acute, with a wide ovate base. The stomach is large, longer than the œsophagus, occupying 8 segments, cylindrical, a little swollen posteriorly, covered with numerous interrupted, irregular, or poorly defined rows of minute cells, not arranged in very definite groups.

A caudal region of about 14 new and small segments is being regenerated on the type.

Length of one specimen (32 segments, caudal segments lacking), 7.5^{mm}; breadth, .75^{mm}; length of œsophagus, 1.38^{mm}; of stomach, 1.6^{mm}. Another specimen (type described) with 57 segments and partly regenerated caudal region is 14.5^{mm} long; 1^{mm} broad; length of œsophagus, 1.40^{mm}; of stomach, 1.60^{mm}.

Color, in formalin, is translucent whitish; the cirri appear distinctly banded with 8 to 10 small dark green spots, every fourth annulus having a very distinct, darkly pigmented area.

Rare—only two specimens were found.

Syllis (Typosyllis) cincinnata, sp. nov.

A strongly colored, rather large species, with numerous compact segments and a highly contractile body; when preserved in formalin usually coiled irregularly, thick and rounded anteriorly, with very short, closely contracted segments, short anterior parapodia; flattened and tapered posteriorly, with longer posterior segments and more prominent parapodia and setæ; antennæ and anterior cirri long, strongly beaded and irregularly curled about the head, so as to nearly conceal it; middle dorsal cirri mostly long, incurved over the back; œsophagus short with a very long tooth; stomach very long and large; blades of setæ mostly rather short, strongly incurved, the anterior ones mostly not bidentate at tip.

The head is small, wider than long, transversely broad-elliptical; buccal segment short. Eyes black, unequal, the anterior rather large and near the sides of the head; posterior ones about $\frac{1}{2}$ as large, separated by about their own diameter, and but little farther back, lens indistinct.

Palpi large, separate to base, longer than head, lanceolate when seen from above, with the inner edge incurved, tips blunt.

Tentacle long and large, the free part projecting twice as far as the palpi, composed of very numerous short annuli, 4 or 5 times broader than long. Antennæ similar, about $\frac{1}{3}$ shorter. Upper tentacular cirri similar, rather stouter and about as long; lower about $\frac{1}{3}$ shorter. Dorsal cirri of about 12 anterior segments are mostly even longer than the upper tentacular cirri, much curled in various directions over the head and back, equal in length to $1\frac{1}{4}$ to $1\frac{1}{2}$ or more times the breadth of the body; farther back in the gastric region they become unequal, some being about as long as the preceding, others only $\frac{1}{3}$ to $\frac{3}{4}$ the breadth of the body, usually recurved over the back; posteriorly most of them are less in length than $\frac{1}{2}$ the breadth of that part of the body. Caudal cirri long, slender, tapered. The anterior parapodia are short and crowded, posteriorly they become well separated and longer, with longer lobes and longer and stouter setæ.

Setæ of the anterior segments are 8 to 10 short and slender, accompanied by 3 or 4 acute acicula, which project but little; the blades of the upper anterior setæ are narrow-lanceolate, breadth to length about 1 : 4–6, with incurved acute tips, sometimes faintly bidentate; the lower ones have shorter blades, ratio 1 : 2 or 3, with more incurved acute tips; the posterior setæ have rather longer and stouter stems, with the blades shorter, wider, ratio 1: 2 to $3\frac{1}{2}$, and with more incurved tips, a few of which are minutely bidentate; there are usually 5 or 6 in a fascicle; the stem is serrulate near the tip; they are usually accompanied by two large, straight, acute acicula.

Œsophagus brown, rather short, thick, in the contracted specimens so bent and crumpled that the length cannot be correctly determined; median tooth large, projecting beyond the margin, the free part equal to the length of two segments, long-conic, acute. Stomach long and rather large, nearly cylindrical, occupying 17 segments, covered by about 36 regular rows of well-separated, small, elliptical groups of cells, with definite lines between the rows.

Color, in formalin, is dull greenish with transverse lines of a darker green on each segment and a dark median dorsal stripe along the back.

Length of largest preserved specimen, 18^{mm}; diameter anteriorly, 1.20 to 1.40^{mm}.

Found among the zoöids of *Palythoa mammillosa* at low tide.

In life the head and anterior part of the body were noted as tinged with orange-red, the head brightest red; eyes orange; posterior

segments dark olive-green ; caudal segments and cirri pink. Some specimens were forming two sexual zoöids at the same time (these were not found in the preserved collection). Two or more species were confused in this lot.

Another specimen (No. 12), supposed at the time to be the same, was described when living, as translucent whitish anteriorly, light green posteriorly; the sexual zoöid was pink and had conspicuous eyes and numerous segments, which were broader than those of the stem-form. This is probably a distinct species, for the œsophagus appears to have a crenulate margin and the median tooth is much smaller.

Syllis (Typosyllis) cincinnata. (Stem-form, with a sexual Zoöid.)

One specimen, in formalin, has part of the dorsal cirri replaced by a thick, ovate pigmented body, with a small terminal papilla, perhaps due to disease. This specimen has a zoöid-head forming at about the 28th segment, with two small brown eyes developed, but special antennæ and cirri are not present, nor any capillary setæ. About 50 segments follow this head. In other respects this individual agrees closely with the type-form described above.

Syllis (Ehlersia) exigua, n. sp.

In addition to the various species described above, a small and very slender or attenuated species was noted, but not fully described. The single specimen is poorly preserved. It is remarkable for the unusually elongated segments. Its generic characters are somewhat doubtful.

The body is composed of about 50 setigerous segments. Head rather broad; palpi short ovate; eyes 6, the four posterior, which are nearly equal, form a trapeze ; the anterior are smaller and nearer together. The antennæ, tentacular cirri, and anterior dorsal cirri are all similar, long and slender with numerous rounded beads; the dorsal cirri of the middle segments are also long, often twice as long as the diameter of the body ; posteriorly they become shorter.

Stomach is short, elliptical, as broad as long, occupying about 2 segments.

The setæ are long and slender; in the anterior 10 segments the upper ones have very long, thin blades, ratio, 1 : 8–1 : 10, the lower ones have the blades about half as long, all feebly bidentate at tip; farther back the blades of the upper ones become shorter; on the posterior segments decidedly so. In each fascicle, there is usually a

single, slender, acute, simple seta, and one spiniform aciculum, often bent at top.

Length, 10mm ; diameter, 3mm.

Syllis (Ehlersia) nitida, sp. nov.

A small slender species with the dorsal cirri and cephalic appendages slender and beaded with rounded annuli, mostly 10–14, and in length generally $\frac{2}{3}$ to $\frac{9}{10}$ the diameter of the body, referred to the subgenus *Ehlersia* because the upper compound setæ have long linear blades, very unlike the lower ones.

Head transversely elliptical, considerably broader than long, distinctly three-lobed in front ; posterior margin broadly rounded, eyes 6, black ; two posterior pairs, which form a short trapeze, are small, nearly equal ; a pair of minute front eyes at bases of the palpi. The palpi are large, broad-ovate, obtuse, rather longer than the head. Tentacle, with about 11 regular rounded beads, is rather longer than the palpi. Antennæ are similar, but shorter, with about 9 beads. Upper tentacular cirri are a little longer than the tentacle ; lower ones much shorter.

The dorsal cirri are all similar and vary but little in length, the largest ones being those along the middle of the body, where some of them are about as long as the diameter of the body and composed of 12–14 beads; they are slender and tapered, and very regularly beaded with rounded annuli, mostly about as long as broad ; the shorter ones are from $\frac{1}{2}$ to $\frac{2}{3}$ the diameter of the body, and with about 8 beads. The anterior dorsal cirri are about equal to the upper tentacular cirri, and have about 12 beads.

Setæ are all compound anteriorly, slender, rather numerous ; 1 or 2 upper ones, all along the body, have long, slender, linear, nearly straight blades with incurved tips, ratios 1 : 10–15, becoming longer posteriorly; the lower ones have much shorter lanceolate blades, ratios 1 : 3–4 ; there is no gradation between the two sorts. Back of the middle the setæ become larger and more differentiated ; the blades of the lower ones are bidentate.

Posteriorly there are usually two spiniform acute acicula, one of which projects considerably.

The œsophagus is long and slender, about twice as long as the stomach ; its tooth is small, conic, close to the margin ; the edge is indistinct, but appears to be finely denticulated. The stomach is narrow-cylindric, covered with many very close rows of glands. Color, in formalin, plain yellowish white. Length, 5mm ; diameter, about 4mm. Only one specimen was taken.

Haplosyllis Langerhans.

Zeitsch. Wissenschaft. Zoöl., xxxii, p. 527, 1879.

This group was made a subgenus of *Syllis* by Langerhans, but it seems to differ sufficiently from that genus to justify its generic separation.

The special character, mentioned by Langerhans, is the presence of simple setæ alone, on all the segments. "Setæ all simple." In our species the shortness and paucity of the setæ are equally noteworthy, for there are usually only one or two short setæ, with a single hooked aciculum, in each fascicle. The simple bidentate setæ have the structure and nearly the form of the stem or shaft of the ordinary form of the compound setæ of *Syllis*, indicating that they are merely such setæ that have lost, or else have not developed, the blade. They are unlike the bifid setæ of *Eusyllis viridula*, which seem to be formed by the consolidation of a short angular blade with the shaft.

Our species of *Haplosyllis* also have the edge of the œsophagus denticulated, nearly as in *Eusyllis*. So that the group appears to be allied to the latter more than to *Syllis*.

The typical genus *Syllis*, as restricted by Langerhans, has simple setæ anteriorly or medially and compound setæ posteriorly. *Typosyllis* has them all compound, or with compound ones on all the segments.

Haplosyllis cephalata, sp. nov.

A small and rather stout species, appearing stouter anteriorly, owing to the prominent head and unusually large palpi; eyes small, black; a few longer anterior cirri; those on most of the body very short, composed of few annuli; setæ simple, bidentate, very few; œsophagus rather short, with a median anterior tooth.

Head thick and convex above, elliptical in outline, widest about the middle, with a slight median lobe anteriorly; posterior edge slightly emarginate. Eyes unusually small, round, black, arranged in a trapeze; the posterior pair are rather small and separated from the anterior by a space equal to 3 or 4 times their diameter.

Palpi very large, wider than the head, ovate, not excavate on the inner margin, obtuse at the end; the exposed part longer than the head, scarcely divergent, but often strongly curved downward in the preserved specimens, with their bases overlapping each other. Tentacle and antennæ long and slender, strongly beaded; the tentacle projects considerably beyond the ends of the palpi; the anten-

næ are shorter, only projecting a little beyond the palpi. The upper tentacular cirri are similar to the tentacle and of about the same length. The lower ones are about ⅓ shorter.

The 1st dorsal cirrus is similar to the upper tentacular cirrus, but longer. The 2d is very much shorter, and the succeeding ones rapidly decrease in length, those beyond the gastric region being only 1/5 to 1/6 as long as the diameter of the body, or even less, and consisting of only a few annuli (often only 3 or 4) and scarcely longer than the parapodia.

Setæ very few; anteriorly there are usually 1 or 2 rather strong simple bidentate setæ and one acute aciculum, which rarely projects; posteriorly there is generally only one bidentate setæ, which is longer and larger than the anterior, and a single aciculum, which often has a bent, hook-like tip. No blades were found on any of the setæ of numerous specimens examined. The bidentate setæ, which correspond to the stems of compound setæ, have a simple, incurved or slightly hooked tip, with a strong triangular tooth below it, the intervening space being concave and oblique. Possibly a blade may be present in the very young. The anterior parapodia are short; the posterior ones become more elongated.

The œsophagus is rather short and wide, pigmented with opaque green, so that its form is not easily seen; median tooth near the edge, acute conical, its end projecting beyond the aperture; margin incurved and usually indistinct, but minutely denticulate, at least in some cases. Soft pharynx with about 10 rounded lobes. Stomach barrel-shaped, usually a little shorter and not much thicker than the œsophagus, opaque, the rows of glands poorly defined; sometimes the stomach and œsophagus are about equal in length, or the stomach may be the longer, owing to the frequently crumpled and contracted condition of the œsophagus.

Color, in formalin, is yellowish white; the tissues are more opaque than in most species. Length, 4 to 6^{mm}; diameter, .5 to .6^{mm}.

Taken in large numbers on one occasion. It inhabits sponges.

Easily distinguished from the young of other species by the large palpi, head, and anterior segments, and the extreme shortness of all the cirri, except those of the head and first segment. The small number of the setæ and their peculiar tips are also characteristic.

This is allied to *H. hamata* of Europe and Madeira, which has the tips of the simple setæ trifid, and to *H. tentaculata* (Mar. 1879, as *S. spongicola*, var.), which has much longer cirri and trifid setæ.

H. streptocephala (Œrst and Grubé), from St. Croix, has longer cirri.

Haplosyllis palpata, sp. nov.

An elongated, slender, somewhat larger species, with large palpi and longer dorsal cirri and setæ than those of *P. cephalata*. The head and antennæ are nearly as in the latter; the palpi are very large and thick, subovate; the body has more numerous and more distinct segments. The dorsal cirri are unequal, but the longer ones, along most of the body, have about 9 or 10 rounded annuli, about as long as broad, and in length are equal to about $\frac{1}{2}$ the diameter of the body. The setæ consist of two or three simple, strongly bidentate setæ, similar to those of the preceding species, but larger and longer, and of one or two acicula, one of which has a small bent tip. The œsophagus is rather long, tubular; its margin is indistinct, but seems to be entire; the tooth is small. *H. Setubalensis* (McInt.) (as *Syllis*) resembles this species in the character of its setæ.

Trypanosyllis attenuata, sp. nov.

Body very long and slender, composed of a large number of rather elongated segments. Cirri all moderately long and strongly beaded with rounded annuli.

Setæ numerous, all compound with rather long narrow blades.

Head about as long as broad, well rounded and slightly three-lobed in front and nearly truncate posteriorly. Eyes 4, small, black, in trapeze, the anterior ones a little larger and situated much behind the middle of the head, at about the posterior third, separated from the posterior by a distance equal to about four diameters of the latter. Palpi large and broad, wider at base than the head, separate to the base, divergent, thick at the base and incurved on the inner margin, very obtuse at the end.

Antennæ and tentacle are gone; upper tentacular cirrus long and slender, composed of about 17 rounded annuli; first dorsal cirrus considerably longer, with about 24 annuli. Succeeding dorsal cirri are all much shorter and somewhat unequal, the longer ones being about as long as the diameter of the body, and composed of 12–14 rounded annuli, mostly about as long as broad, or a little longer distally; the shorter cirri are about $\frac{3}{4}$ as long. Similar cirri continue to the end of the body, gradually decreasing in size.

The caudal cirri are long and slender, their length being equal to the diameter of the body in its middle, composed of about 13 annuli, which are mostly longer than broad.

The setæ are numerous and slender, about 10–12 compound ones in the anterior fascicles, with three or four small slender acicula that do not project. The blades of the upper setæ are narrow and nearly

straight, ratio about 1 : 6–9, with the tips very minutely bidentate and slightly incurved ; the lower ones are shorter, ratio about 1:4–5, but of the same form. Posteriorly they become larger and longer, with stouter stems, usually 5 or 6 in a fascicle, and the blades are somewhat broader and more distinctly bidentate at tip, but the change is very gradual.

The œsophagus is very long and slender, straight, occupying 17 or 18 segments; its edge is divided into a circle of about 10 rounded or obtuse scallops ; median tooth small, close to the edge; soft pharynx, when extended, elongated, its margin with about 10 large rounded lobes, longer than broad, the seven upper ones longer than the lower. The stomach is small, oblong-elliptical, occupying 4 segments ; it is covered by about 26 rows of small cell clusters.

Color, in formalin, yellowish white ; œsophagus and stomach pale.

Length, about 16^{mm} ; diameter, .25 to .30^{mm}.

Dredged off Bailey Bay, in 5–6 fathoms, shell-sand.

Typanosyllis fertilis, sp. nov.

A species of medium size, with a large and broad head and wide palpi; rather long, strongly beaded dorsal cirri; numerous and long setæ, the posterior ones decidedly longer and stouter than the anterior, with a short, wide, distinctly bidentate blade. The female has the posterior half of the body distended with large polygonal eggs, but has no special sexual setæ.

Head unusually large and wide, broader than long, with the sides very prominent and convex behind the eyes, concave farther back ; front edge prominent, three-lobed ; posterior margin narrow, emarginate. Eyes of moderate size, brown, the anterior a little larger, farther forward and farther apart, distant from the posterior by 3 or 4 diameters. Palpi large and broad, their bases rather wider than the head, their free part about equal to the length of the head, broad-ovate, blunt, the inner edge concave. Tentacle slightly tapered, strongly beaded, composed of 16 annuli, the free part about twice as long as the palpi ; distal annuli about 1½ times wider than long, the middle ones about ½ as long as wide. Antennæ similar but shorter, only their two distal annuli extending beyond the palpi. Upper tentacular cirri similar to the tentacle and of the same length, consisting of 15 annuli ; lower ones about ½ as long. Dorsal cirri on several (about 12) anterior segments mostly similar to the tentacle, but ¼ to ⅓ longer, and are equal to or considerably exceed the diameter of the adjacent segments. Along the rest of the body the dorsal

cirri are more unequal, but the larger ones are longer than those of the anterior segments, composed of 18 or 19 annuli, and often exceed the diameter of the body by $\frac{1}{4}$ of their length ; the shorter ones are about $\frac{2}{3}$ as long with 14 or 15 annuli.

The setæ of the anterior parapodia are numerous, long and slender, with delicate narrow-lanceolate blades, slightly bidentate at tip, the upper ones longer, breadth to length about 1 : 4 or 5, in the lower ones about 1 : 3 or 4. In the anterior parapodia there are also 3 or 4 slender acute acicula, side by side, but usually not projecting. Posteriorly the compound setæ become longer and slender, 7–9 in a fascicle, with larger and shorter blades, ratio as 1 : $1\frac{1}{2}$–$2\frac{1}{2}$, with the tips strongly incurved and distinctly bidentate. These are accompanied by 2 or 3 stouter spiniform acicula, one of which usually has the tip somewhat hook-shaped.

In the type the segments, commencing somewhat forward of the middle, from about the 33d segment, are crowded with ripe eggs, which are polygonal from pressure.

Œsophagus brown, rather long and large, occupying 7 segments, cylindrical, with a short stout tooth near the margin; edge divided into about 10 rounded lobes or scallops, recurved when extended. Soft pharynx with about 10 low, broad, rounded lobes.

The stomach is light greenish, deeply pigmented, and opaque, nearly $\frac{1}{2}$ as long as the œsophagus and more than twice as thick, occupying 5 segments, somewhat barrel-shaped, or elliptical, widest posteriorly and covered with an alveolar arrangement of polygonal glands separated by narrow dark lines so as to have a honey-comb-like appearance externally, unlike that of other species.

Color of the preserved specimens is plain yellowish-white.

Length of type, about 24^{mm} (caudal segments gone) ; diameter $.6^{mm}$.

This appears to be a species that does not produce special sexual zoöids. The large size and form of the head ; the character of the setæ ; and the alveolar surface of the stomach, are its most notable diagnostic characters. It appears to be rare.

Trypanosyllis tenella, sp. nov.

A small, slender species, with long beaded cirri, which is doubtfully referred to this genus on account of the strongly denticulated or scalloped margin of the œsophagus ; in most other respects it closely resembles the young of *Syllis corallicola* and *S. catenula*, but it has a narrow stomach and the setæ are more bidentate, at tip.

Head small, the anterior portion nearly semicircular, deeply emarginate or cordate behind, well rounded in front, but with a slight median lobe, sides evenly rounded, most convex opposite the eyes, which are about equal, rather small, black, arranged in a short trapeze, the distance between the anterior and posterior about equal to two diameters ; a pair of minute black ocelli at the anterior margin in front of the antennæ.

Palpi large and long, lanceolate, regularly tapered, longer than the head, obtuse. Tentacle shorter than the antennæ, of 8 annuli, equal to the palpi, tapered, its distal annuli longer than broad. Antennæ similar, but about $\frac{1}{4}$ longer, of 13 annuli, about 3 or 4 distal annuli projecting beyond the palpi. Tentacular cirri long and slender with rounded annuli, about as long as broad ; upper ones, with 18 annuli, are longer than the antennæ, lower ones about $\frac{2}{3}$ as long. Dorsal cirri of segments 1, 3, 4, 6, and many others are longer than the tentacular cirri, composed of 22–28 annuli, and about twice as long as the diameter of the body; shorter ones irregularly alternating are $\frac{1}{2}$ to $\frac{2}{3}$ as long. Caudal cirri long and slender, tapered, similar to the longer dorsal cirri.

Setæ rather numerous, long and slender, all compound and similar ; the upper anterior ones have slender lanceolate blades with bidentate tips, ratio about as 1 : 4 or 5 ; of the lower ones about 1 : 3 or 4. Posteriorly the blades are shorter and the tips are more incurved and more strongly bidentate, with the denticles divergent, ratio about 1 : 2–2½ ; these are usually accompanied by 1 or 2 rather stouter spiniform acicula, with the tips slightly projecting, that of one usually somewhat hooked, the other only a little bent.

The œsophagus is rather long, occupying 8 segments, but not slender, wrinkled transversely in the type and somewhat contracted at each end ; its margin is emarginate on each side and is divided into a number of rather small, not very regular, obtuse denticles or scallops ; the tooth is close to the edge and rather small; the soft pharynx is divided into a circle of rounded lobes. The stomach is elongated, narrow, cylindric, occupying 8 segments, about equal in length to the œsophagus, and not much larger; its surface is covered with 50 to 55 close rows of opaque cell-groups ?. Color, in formalin, plain yellowish white. Length, about 11^{mm} ; diameter, .6^{mm}.

This species is very distinct from *T. vittigera* Ehlers, which is a large brownish species conspicuously marked by two transverse, narrow, white bands on each segment, and with the denticles of the œsophagus large and subtruncate. The setæ have short, bidentate blades. The latter was taken by us in considerable numbers.

T. gigantea McInt. (Chall. Voy.) as *Syllis*, appears to be closely allied to this last species.

Hemisyllis, gen. nov.

Similar to *Eusyllis*, but with the large palpi united together for about half their length in front of the head. Antennæ, tentacle, and anterior cirri long and beaded, as in *Syllis*; œsophagus straight, with the front edge serrulate; median tooth submarginal. Setæ few and simple, bidentate, without blades.

Hemisyllis dispar, sp. nov.

A small species with broad head and palpi, the lobes of the palpi projecting forward from the swollen common base which looks like a part of the head.

Head large and broad, the anterior half nearly semicircular; the front margin well rounded, apparently coalescent with the palpi in the middle; sides most prominent posterior to the eyes; posterior margin broadly convex. Eyes 4, small, black, in a trapeze, the anterior larger, not very close to the sides of the head; the posterior are very small, separated by about 4 diameters from the anterior ones. Palpi very large and wide, their bases thick and swollen, united together for about half their length, the front edge of the common base convex between the separated free lobes, which are narrow-ovate and obtuse.

Tentacle, antennæ, and all cirri are all similar in form, tapered and strongly beaded with rounded annuli, which on the middle and distal parts are as long as wide, or even longer than wide, and elliptical toward the end. The tentacle has about 20 beads and is about as long as the head and palpi combined; the antennæ are rather shorter, with 18 beads. The upper tentacular cirri are longer and rather stouter, with about 20 beads; the lower are about $\frac{2}{3}$ as long. The first dorsal cirrus is longer than the tentacular cirrus and has about 22 beads; its length is about $1\frac{1}{2}$ times the breadth of the segment; second cirrus is about $\frac{1}{3}$ as long, with 9 beads; third and fourth are rather longer than the second, with 14 beads; farther back they decrease rapidly, so that back of the stomach most of them are quite short, mostly with only 2–4 beads. The ventral cirrus is papilliform. Caudal end is lacking.

The setæ are few, small, and short; in the anterior region there is, in each fascicle, only 1 small bidentate seta (without blade, in the type), and 1 slender aciculum, with a small hooked tip, scarcely projecting.

The œsophagus is long and slender, occupying 7 segments; its edge is denticulated with small, unequal, acute teeth; median tooth

is small, close to the margin. The stomach is large, in length about equal to the œsophagus, long-elliptical, occupying 6 segments; it is covered with about 38 crowded rows of small, dark, round or elliptical glands. Color, yellowish white. Diameter of the type, .4^{mm}; the posterior half is lacking. Only one specimen was found.

Opisthosyllis Langerhans, op. cit., p. 541, 1879.

Palpi, body-segments, setæ, and cirri as in *Syllis* (*Typosyllis*). Œsophagus large and rather short, cylindrical, with the anterior margin entire; median tooth near the posterior end. Stomach large, its glands very distinct. Head pyriform, widest in front; palpi long and divergent. Buccal segment forms a collar.

Opisthosyllis nuchalis, sp. nov.

A large elongated species with numerous rather long, beaded cirri. Œsophagus large, showing as a conspicuous, brown, oblong patch on the back of the anterior segments.

Head pyriform, widest close to the anterior margin, which is truncate or slightly emarginate in the middle and on either side, so that it is slightly four-lobed; the sides are convex, narrowing backward, the posterior end narrow with a small emargination between two angular lobes. Eyes yellowish brown, small, nearly equal, prominent, with a convex lens; the anterior are wider apart, the four forming a trapeze. Palpi large, divergent, longer than the head, lanceolate, the distal half rapidly tapered, tips subacute, inner margins excavated.

The buccal segment is transversely narrow, and its anterior edge is extended forward as a rather broad, thin collar, conspicuous on the sides, where it extends as far forward as the anterior eyes and almost to the bases of the palpi, but receding dorsally, so as to expose the posterior eyes. The first and second setigerous segments are a little wider than the buccal and the breadth of the body suddenly increases at the third segment, where the end of the œsophagus is situated in the type specimen, but this is probably due, in part at least, to the pressure used in mounting it.

Tentacle and antennæ are slender, tapered, strongly beaded with small annuli, the distal ones are as long as broad, the proximal short and indistinct; the tentacle is considerably longer than the palpi, and contains about 24 annuli; the antennæ are but little longer than the palpi. Upper tentacular cirri are larger and about $\frac{1}{3}$ longer than

the tentacle, or about twice as long as the breadth of the buccal segment; lower ones about $\frac{1}{3}$ shorter. The first dorsal cirrus and most of the others on the anterior half of the body are longer than the upper tentacular cirrus and contain 36–40 annuli; these long cirri are regularly tapered, more or less curled, regularly beaded distally, and equal or somewhat exceed the diameter of the body. Others not more than half as long occur irregularly.

Setæ are all similar, long and numerous, 8–10 in a fascicle, larger than usual in this family, with rather short, wide blades, the ratio of width to length about as 1 : $2\frac{1}{2}$–$3\frac{1}{2}$; their tips strongly incurved, simple and acute. The posterior setæ and acicula are rather larger and longer than the anterior, but similar in form; two acicula, larger and more yellow than the setæ, occur in most fascicles; their tips are a little blunt or enlarged, and seldom project. Posteriorly there are often one or two simple acute setæ. The stems of the compound setæ are very oblique at the enlarged end, and have a rounded lobe just below the tip, on the outside.

The œsophagus is deep brown, as wide as the stomach and $\frac{2}{3}$ to $\frac{3}{4}$ as long, nearly cylindrical, but usually a little swollen in the middle and slightly contracted posteriorly. Its aperture is wide and nearly even, with a narrowly revolute entire margin. There is no anterior armature, but a small, rounded, highly refracting spot near the posterior end indicates the existence there of a posterior tooth, which bends inward and forward, with an acute tip, the base being much wider than the tooth itself.

The stomach is large and long, occupying about 12 segments, cylindrical, pale colored, covered with very distinct and well-separated roundish or elliptical groups of greenish glandular cells, arranged in about 70 pretty regular rows; on the posterior half a whitish line ususally runs along the middle of each row, so as to divide the most of the groups of cells into two nearly equal parts; anteriorly this line, or membrane, runs between the rows. Each glandular cluster seems to rise, with a narrow stem, from the center of a whitish, square or polygonal area, bounded by fine lines. They are arranged so regularly in quincunx that when not much magnified they have a tessellated appearance. Seen in profile the glandular groups are long-pyriform, with a narrow base. Other small irregular groups are scattered between the regular rows.

The color of the type specimens, in formalin, is yellowish white, with a dark brown oblong spot anteriorly, due to the œsophagus.

Length of the larger specimens, 20 to 25^{mm}; diameter, 1.4 to 1.6^{mm}.

In dead corals from the reefs.

Var. ? gularis.

One specimen, differently preserved, and much contracted, is rather deeply tinged with green, and has a narrow dark line across the front part of the anterior segments, and pale sutural lines; there is also a dark median stripe posteriorly. This was one of the specimens mixed with *Syllis cincinnata* and noted, in life, as having the anterior parts orange-red and the posterior olive-green (see page 610).

This may, perhaps, be an additional species of *Opisthosyllis*.

The posterior tooth of the œsophagus is more distinct. The stomach is much like that of the type described above. The cirri and antennæ are shorter and more curled, the longer ones about ½ the diameter of the body, but the entire body and the appendages are much contracted.

The anterior setæ are fewer, stouter, and longer than in the type of *nuchalis*, especially the upper ones, on which the blades are shorter and wider, with incurved tips, which are not bidentate.

The posterior setæ are decidedly longer and stouter than the anterior, with very oblique, shorter incurved blades, all with acute tips. Two stout acute acicula occur in the posterior fascicles; three in the anterior.

Length, as contracted, 10.5^{mm}; diameter, 1.2^{mm}; much longer in life.

Bailey Bay, at low-tide, in *Palythoa*.

Eusyllis (Synsyllis) viridula, sp. nov.

A small, very slender, pale green syllid with short, slender dorsal cirri scarcely longer than the breadth of the body; œsophagus long, slender, with the margin minutely denticulated; stomach long; palpi rather short.

The head is transversely elliptical, with the middle of the front margin slightly prominent and the posterior margin a little emarginate. Eyes small, light brown.

Palpi separate to base, nearly regularly broad-ovate, about as long as the head, obtusely rounded at the end and not concave on the inner margin.

The antennæ are scarcely tapered, rather short, about equal to the breadth of the head, projecting somewhat beyond the palpi, consisting of about 9 annuli, the distal ones well defined. The upper tentacular cirri are about ⅓ longer and rather stouter; the lower ones are about equal to the antennæ in size and length.

The dorsal cirri on segments 1–4 are rather more slender than the upper tentacular cirri but of about the same length and about equal

to the breadth of the body, with well-defined annuli, those on the distal portion being rather longer than broad. Farther back the cirri gradually become shorter and more slender, but unequally so, longer and shorter ones often alternating, the longer ones scarcely equal to $\frac{3}{4}$ the breadth of the body, composed of about 12 annuli, the shorter about half as long. Back of the gastric region the cirri become shorter and more nearly alike, equal to about $\frac{1}{3}$ to $\frac{1}{4}$ the breadth of the adjacent segments, composed of 6 to 8 annuli, tapered, and subacute. The ventral cirri are ovate, nearly as long as the setigerous lobes. The parapodia are large and the segments are rounded and separated by well marked constrictions.

The setæ are few; in the anterior fascicles there are usually 4 or 5, all compound, with slender stems; the upper ones have slender lanceolate blades, 4–6 times as long as wide; the lower ones have shorter blades, 2–2½ times as long as wide; the tips are incurved and most of them are very minutely bidentate. One or two slender subacute acicula are usually present, but they rarely project beyond the ends of the parapodia. Posterior to the stomach the setæ are reduced to 2 or 3 long compound ones, with very short blades; from segments 20–22 they are replaced by 1 or 2 simple bidentate setæ or crotchets, but compound setæ may have existed on the lost caudal segments; the posterior setæ are much longer than the anterior, with a much stouter stem, terminating in a bifid or two-pronged tip, evidently due to the consolidation of a short blade with the stem. There are usually two stout acicula, one with a blunt tip and the other hooked.

The œsophagus is very long and slender, occupying about 12 segments; it has a bulbous swelling a little back of the anterior end; the margin is a little emarginate, with the dorsal side longer; the edge is finely denticulated; the tooth is large and elongated, acuminate, with a sharp tip which projects beyond the edge. The stomach is nearly opaque, whitish, rather long and thick, occupying 6 segments. It is covered with about 38 rows of distinct rounded groups, separated by definite narrow lines of green cells, which unite in the median line to form a row of angular groups.

The color in formalin is pale green with a darker green line across the middle of each anterior segment, above; stomach opaque, whitish.

Length of the type, without caudal segments, 15^{mm}; diameter, .5^{mm}.

Eusyllis (Synsyllis) longigularis, sp. nov.

Body long and slender with short dorsal cirri, and a long slender œsophagus, minutely denticulate at the margin. Head small, rather

wider than long, and slightly trilobed anteriorly, emarginate posteriorly. Eyes small, black, the anterior ones a little larger and farther apart. Palpi large, divergent, the free part rather longer than head, the inner margin concave, tips obtuse. Tentacle slender, tapered, rather short, extending about to ends of palpi. Antennæ tapered, somewhat shorter and smaller, distinctly beaded, with 8 to 10 annuli. Upper tentacular cirrus similar in form, about twice as long as tentacle, with about 15 annuli; lower one smaller, about ½ as long, with 8–10 annuli. The first and some of the other dorsal cirri are as long as, or longer than, the dorsal tentacular cirri, and equal to about twice the breadth of the first segment. In the type longer cirri occur on segments 1, 2, 4, 6; shorter ones on 3, 5, 7, 8. Farther back the longer dorsal cirri are mostly less than the diameter of the body, and on the posterior half they are equal to about ½ the diameter of the corresponding segments. They are all tapered and neatly beaded. Caudal cirri larger than the adjacent dorsal cirri and twice as long.

The anterior setæ, 5–7 in a group, have the blade narrow, nearly straight, 3 to 3½ times as long as broad; shorter below and on the more posterior segments; the tips minutely bidentate. Setæ beyond the 20th segment are reduced to 2 or 3 in each fascicle, much longer and stouter than the anterior ones and about equal to the dorsal cirri; the longer one is a two-pronged crotchet; on the compound ones the blades are short, ratios 1 : 1¼–1¾, the tips bidentate; on the last 10 segments the setæ are all compound. They are accompanied by 1 or 2 spiniform acicula.

The œsophagus is brown, very long and slender, occupying about 13 segments; its tooth is near the front margin, which is unevenly finely serrulate with about 16 denticles. The stomach is narrow, cylindrical, rather short, occupying about 5½ segments,* with many crowded rows of small cell-groups and a median sulcus. Color, yellowish white. Length, in formalin, about 15^{mm}; diameter, .5^{mm}.

Branchiosyllis lamellifera, sp. nov.

A small greenish syllid with compact segments, wide truncated head, blunt falcate palpi, beaded dorsal cirri, and large parapodia, having a leaf-like gill on their anterior side. Setæ with short blades.

Head large, broader than long, widest near the front; the anterior margin nearly straight, but has a small rounded lobe in the middle;

* The number of segments occupied by the stomach or œsophagus varies considerably in all the species, owing to the great contractility of the segments. It is a character of some value, however, if taken relatively.

sides rounded, but narrowing backward, posterior margin cordate-emarginate in the middle. Eyes 4, rather large, nearly black, placed in advance of the middle, nearly in a transverse row, the posterior ones being $\frac{1}{3}$ smaller and a little farther back, distant less than their diameter from the others. Palpi broad, obtuse, with the inner edge incurved and the ends usually bent downward, the free part about as long as the head.

The tentacle is short, tapered, scarcely longer than head, reaching but little beyond the ends of the palpi, basal part not beaded, the two or three distal beads more evident. Antennæ like the tentacle, but shorter.

Tentacular cirri are large, but not very long, scarcely tapered; the upper one is about $\frac{1}{3}$ longer than the lower, composed of 14 annuli, the distal ones being nearly as long as broad, and separated by deep constrictions. The first dorsal cirrus is similar to, and about $\frac{1}{5}$ longer than the upper tentacular cirrus, or about $1\frac{1}{2}$ times longer than the diameter of its segment; the second is less than $\frac{1}{2}$ as long; the third is longer than the first. Farther back the cirri are variable in length, part of them being rather longer than the breadth of the body and others not half as long, of about 10–12 annuli. The parapodia are large and prominent; the setigerous lobe terminates in two small papillæ; the ventral cirrus is stout and nearly as long as the setigerous lobe.

The gill is present on all the segments; beginning as a small rounded lobe anteriorly, it increases to an ovate form a little farther back; along the middle region of the body it becomes much larger, broad, foliaceous, with three or sometimes four lobes, becoming more simple and smaller posteriorly. The larger ones are as long as the thickness of the parapodia and considerably wider.

Setæ are large and long. The compound ones, of which there are usually 2 to 4, have a small and short incurved blade, wider at base, with an acute, hook-like tip; the length is about equal to the breadth. With these there are one or two somewhat stouter, acute acicula, with the tips slightly bent and projecting but little or not at all beyond the setigerous lobes.

The œsophagus is small, cylindrical, short, occupying 5 or 6 segments, light colored, cylindric, with a stout, conical tooth near the dorsal edge; the margin is indistinct, but appears to be finely irregularly denticulated. The stomach is thick, pale in color, and slightly longer than the œsophagus, occupying 6 segments.

Color, in formalin, light green, with indication of a broad, darker greenish band across each segment; in one specimen there is a pale line between the segments and a row of darker roundish spots with pale centers along each side; the gills were apparently dark green. The color in life was not noted.

Rare, only three specimens seen, none perfect.

It is closely related to *B. oculata* Ehlers, from Florida, described from a single small, imperfect specimen, but the latter has smaller and shorter simple gills, and a differently shaped head.

Desmosyllis longisetosa, sp. nov. (See p. 635.)

A small, slender, 6-eyed species with long, well-beaded antennæ and dorsal cirri; setæ of two kinds, compound and simple; the upper anterior have long, slender, acute blades.

Head broader than long, widest in front of middle, with the posterior border emarginate and the front with a medial lobe. Palpi short and broad, oblong ovate, united for about $\frac{1}{3}$ their length, wider than the head and about as long. The four larger eyes are black and conspicuous, though small, the anterior are a little larger and much farther apart, though only a little farther forward; the third pair are minute, situated at the bases of the antennæ. The tentacle is large and long, 5 or 6 times as long as the head, composed of about 28 annuli, of which 23 are beyond the ends of the palpi; the annuli are mostly about $1\frac{1}{2}$ times wider than long, but the distal ones are about as long as broad, elliptical, with deep constrictions between.

The antennæ are similar and nearly as stout as the tentacle and about $\frac{3}{4}$ as long, with about 24 beads. The upper tentacular cirri are like the tentacle and longer, projecting forward nearly as far; the lower ones are about half as long. The dorsal cirri are all long and strongly beaded, but those of the first 10 segments are particularly long, some of them being nearly twice the length of the upper tentacular cirri and 5 or more times as long as the diameter of the body, with about 38 annuli; those left near the posterior end are about 4 times the diameter of the corresponding segment, but most are lost posteriorly.

Ventral cirri slender, tapered, nearly as long as the setigerous lobes. Setæ are numerous and long; those of the anterior fascicles have the free part longer than half the diameter of the body; the posterior are equal to the breadth of the corresponding segments; the upper anterior setæ have long, narrow, straight blades, 8–10 times as long as wide, with the tip incurved and faintly bidentate; the

lower ones have the blades only 4 to 6 times as long as wide; the posterior fascicles have numerous similar compound setæ and also one slender, acute, simple straight seta, usually rather shorter than the rest; a smaller simple seta occurs in many anterior fascicles.

The œsophagus is short, with a median tooth, but its margin could not be distinctly seen. The stomach is short, occupying about 6 segments, strongly elliptical, covered with regular rows of squarish cell-clusters.

Odontosyllis enopla, sp. nov.

A large species with a dark brown, wide, short œsophagus, armed with a ventral row of six stout, recurved, hook-like teeth anteriorly, besides the median dorsal tooth.

Head large, broader than long, broadly rounded in front and on the sides; posteriorly with two rounded lobes, separated by a small median emargination. Eyes black, unequal, the anterior ones much the larger, reniform; those of each side are so close together that they seem to be almost in contact.

Palpi shorter than the head, rather wide, thin, often wrinkled or folded in contraction, and commonly curved downward.

Tentacle tapered, rather slender, not annulated, its length about $1\frac{1}{2}$ times that of the head. Antennæ similar, about $\frac{1}{2}$ as long. Tentacular cirri similar to the tentacle, the upper one rather larger and longer; the lower ones shorter; first dorsal cirrus decidedly longer and larger than the upper tentacular cirrus. Succeeding ones mostly shorter, unequal, alternately shorter and longer, tapered distally; the longer ones are equal to the breadth of the body, the shorter ones about $\frac{1}{2}$ as long; those on setigerous segments 3, 4, 6, 9 are longer than the others.

The setæ are all similar, numerous, slender, short, projecting but little beyond the parapodia, with short rather wide blades, ratio as $1 : 2\frac{1}{2}$–3; their tips are strongly incurved and acute, with a small denticle a little distant from the end. Two spiniform yellow acicula usually occur in each fascicle.

The œsophagus is short and occupies about 4 segments; its margin is incurved and strongly emarginate dorsally. It bears a group of 6 nearly equal, parallel, recurved hooks or teeth, which are large and strong. The conical dorsal tooth is near the margin.

The stomach is large and occupies 8 segments; it is wide, elliptical, and about twice as long as the œsophagus. Its surface is cov-

ered with angular or alveolar markings, often hexagonal, so as to have a honeycomb-like appearance, but not arranged in definite rows.

Color, in formalin, is nearly white, except when containing eggs.

Length, 25^{mm}; diameter, about 1.5^{mm}.

One of the largest specimens has all the segments back of the gastric region filled with eggs.

Odontosyllis brachydonta, sp. nov.

Similar to *O. enopla* in size and form, but easily distinguished by the very short tapering œsophagus and the much smaller size of its ventral teeth, and by the 4 well separated eyes.

Head large, but smaller and narrower than in *O. enopla*, deeply emarginate in front and with two prominent lobes, most prominent and somewhat angular in front of the anterior eyes; sides broadly convex; posterior margin cordate-emarginate.

The buccal segment extends forward as a collar with median and lateral lobes. Tentacle without articulations, stout at base, rapidly tapered, in length about equal to the breadth of the head. Antennæ similar, about $\frac{1}{3}$ shorter. Upper tentacular cirri and many of the dorsal cirri are larger and $\frac{1}{4}$ to $\frac{1}{3}$ longer than the tentacular cirri, but similar in form, usually curled in contraction; the longer ones exceed the diameter of the body. Setæ numerous and crowded, slender, with small and short blades, ratio about 1 : 2–3; the tips are distinctly bidentate, with the denticle somewhat removed from the strongly incurved tip. Œsophagus dark umber-brown, very short, about as broad as long, with the base nearly twice as broad as the anterior end; its edge is narrowly revolute; the 6 ventral teeth are small and short, with angular bases, in a regular row; the four central teeth are larger than the lateral; median tooth near the dorsal margin. Stomach large, long-elliptical, light colored, shorter than in *enopla*.

The only specimen found has lost the caudal portion. It is similar to *O. enopla* in size. Each anterior segment is crossed by a narrow dark line.

Grubeosyllis nitidula, sp. nov. (See p. 634.)

A very small, slender, nearly smooth species, consisting of about 25 setigerous segments; the antennæ and all the cirri fusiform with slender acuminate tips; eyes large, black; setæ with relatively long blades.

Head rather large for the body, evenly rounded in front and on the sides, subtruncate posteriorly. Eyes are conspicuous; the anterior ones are about twice as large as the others and farther apart, the distance between being about equal to the diameter of a posterior eye.

Palpi large, broader than the head, united together nearly to the tips, which are separated by a notch or emargination; the length of the projecting portion is equal to the length of the head.

Tentacle is as long as the head and palpi combined, slender, somewhat fusiform proximally, the tip long and acuminate, without distinct annulations, but with some very minute rough points. Antennæ similar in form, but about $\frac{1}{5}$ shorter. Tentacular cirri two on each side, of about the same length, and like the antennæ in size and form. First dorsal cirrus like the tentacular cirri, but about $\frac{1}{3}$ longer. The following cirri are about equal to the tentacle in length, or nearly equal to the diameter of the body; nearly smooth, but showing a few scattered, minute, conical papillæ when highly magnified. The anterior parapodia are rather long, equal to about $\frac{1}{3}$ the breadth of the segment.

The compound setæ are long and rather numerous; the upper ones have a long, slender, nearly straight, acute blade, ratio about 1 : 8–12; the lower ones have shorter blades, ratio 1 : 5–6. In most fascicles there is also a single, slender, needle-like seta, about as long as the others.

The œsophagus is short and rather stout, occupying about 3 segments, and in length about equal to the stomach, which is thick and nearly cylindrical, occupying $2\frac{1}{2}$ segments; it is covered with close rows of dark clustered cells.

Grubeosyllis rugulosa, sp. nov.

A very small species with 28 segments, with the dorsal surface of the body and cirri roughened with minute conical papillæ.

Eyes well developed, dark brown, close together. Palpi large, united nearly to the tips, longer than the head, a little broader than long. Tentacle and antennæ of about the same form and size, shorter than head, fusiform, with a small acuminate tip. Tentacular cirri short, similar to the tentacle in size and form, nearly equal. Dorsal cirri all short and much like the tentacular cirri.

The compound setæ are rather long and slender, usually 4–6 in a fascicle; in the anterior fascicles the upper ones have rather long, narrow, slightly curved blades, and the lower ones blades about half as long and more incurved; posteriorly they are all shorter and

more incurved. In each fascicle there is usually one slender, needle-like, acute seta, nearly as long as the others.

The œsophagus is rather short, but $\frac{1}{3}$ longer than the stomach, with a large tooth. The stomach is short elliptical, as broad as long, and occupies but one segment. The parapodia and setæ are prominent, especially posteriorly, where they are as long as the breadth of the body; anteriorly they are about $\frac{1}{2}$ its breadth.

Length, 3^{mm}; diameter, $.2^{mm}$.

Only one specimen was found.

Autolytus (Proceræa) simplex, sp. nov.

A small, slender species with long slender tentacle and antennæ, and three pairs of cirri that are still longer, other dorsal cirri short. Head small and rounded; eyes black, rather large, those of the same side in contact or nearly so, the anterior a little larger; a few black pigment cells at the front border of the head may represent a pair of ocelli. Palpi small, rounded, united.

Antennæ and tentacle similar, long, slender, smooth, scarcely tapered, with slight indications of articulations, three or four times as long as the head and palpi combined. Tentacular cirri similar to the tentacle in size and form, the upper ones nearly twice as long; lower ones about equal to the antennæ. First and second dorsal cirri are like the upper tentacular cirrus, or a little longer. All the succeeding cirri are small and very short, the length from $\frac{1}{6}$ to $\frac{1}{2}$ the diameter of the body. Caudal cirri long and tapered, distinctly annulated.

The setæ are all essentially alike; anteriorly there are 6–8 in a fascicle, with the stems slender and subclavate, the blades are small and very short, ratio about as $1 : 1\frac{1}{4}$ to $1\frac{1}{2}$; their tips are slightly incurved and minutely bidentate at the end.

The œsophagus is long, slender, and folded, occupying 11 segments. The stomach occupies 5 segments; it is rather short, cylindrical, narrowed at both ends, with numerous close, narrow rows of glands.

The bases of the parapodia back of the stomach are swollen, rounded, and dark colored, causing a conspicuous lateral row of spots on each side, which extend forward nearly to the head.

A constriction occurs at the 40th segment, indicating the formation there of the head of a sexual zoöid, which has two small eye-specks, but no special appendages are present. The zoöid contains 21 segments and is already full of eggs.

Length, 5^{mm}; diameter, $.25^{mm}$.

In addition to the numerous species of Syllidæ described above, there are, apparently, single specimens of several others, but some of them are not perfectly preserved, and others are so contracted that essential features, like the armature of the œsophagus, cannot be made out without destroying the specimens. Among these there are, apparently, another *Trypanosyllis*, an *Autolytus*, and perhaps an additional *Eusyllis*. Many additional Syllidæ will probably be discovered at the Bermudas when carefully sought for, especially at different seasons of the year.

Autolytus (Proceræa) rubropunctatus (Grubé).

Sylline rubropunctata Grubé, Arch. fur Naturg., 1860, I, p. 87, pl. iii, fig. 8.

Autolytus (*Proceræa*) *ornatus* Mar. & Bobr., Ann. Sci. Nat., Ser. 6, II, p. 44, pl. v, figs. 14–14d, 1875. (*non* Verrill, 1874); St. Joseph, Ann. Polych. Cotes Dinard, Annales des Sci. Natur., Ser. 7, vol. 1, p. 220, pl. x, figs. 98, 99, 1886.

Proceræa rubropunctata Lang., Zeits. fur Wissen. Zoöl., xxxii, p. 579, pl. xxxii, figs. 30*a*, 30*b*, 1879.

This European species has also been recorded from Beaufort, N. C., and is, therefore, likely to be found at the Bermudas.

It is peculiarly marked with a transverse row of four orange spots on each segment, and has larger palpi than usual in this group.

The species originally named *Stephanosyllis picta* V. in 1874, was soon afterwards changed by me, (Amer. Jour. Sci., 1874) to *Stephanosyllis ornata.* Since *Proceræa* and *Stephanosyllis* are now generally considered synonymous, that specific name cannot be used for the European species. It should be designated as above indicated.

Our New England species may bear the name *A.* (*Proceræa*) *ornatus*, unless some reliable characters can be found for the separation of *Stephanosyllis.*

Analytical table of the Genera of Bermudian Syllidæ, described above.

I.—Palpi large, separate to their bases.

A.—Œsophagus with only a single median tooth. Antennæ and cirri moniliform.

B.—Parapodia without a branchial lobe.

C.—Median tooth near anterior end of œsophagus.

D.—Margin of œsophagus entire or nearly so. *Syllis.*

a.—Setæ all compound and similar, but differing somewhat in relative length of blades. Subgen., *Typosyllis.*

aa.—Upper anterior setæ with abruptly longer, narrow blades. Subgen., *Ehlersia.*

aaa.—Setæ few, simple, without blades; end bidentate. *Haplosyllis*, sp.

DD.—Margin of œsophagus dentate or serrulate.

b.—Margin serrulate or finely dentate.

c.—Setæ all, or in part, compound. *Eusyllis.*

cc.—Anterior setæ compound; those of middle region mostly two-pronged crotchets. *Synsyllis.*

ccc.—Setæ few; all simple with bidentate ends. *Haplosyllis.*

bb.—Margin strongly dentate or scalloped.

d.—Œsophagus straight. *Trypanosyllis.*

dd.—Œsophagus folded, slender. *Pterosyllis.*

CC.—Median tooth of *œsophagus* near its posterior end; margin entire; opening wide. A buccal collar. Setæ mostly compound; blades acute. *Opisthosyllis.*

BB.—Parapodia with a branchial lamella. Setæ all compound, with acute, claw-like blades. *Branchiosyllis.*

AA.—Œsophagus short, with a ventral row of recurved teeth. Cirri not moniliform. Setæ compound, with acute, incurved blades. *Odontosyllis.*

II.—Palpi large, more or less united medially. Œsophagus with a median tooth.

e.—Palpi only partially united. Antennæ and cirri long, moniliform.

g.—Setæ all simple with bidentate ends. *Hemisyllis.*

gg.—Setæ mostly compound; simple setæ acute. *Desmosyllis.*

ee.—Palpi united nearly or quite to their tips. Antennæ and cirri short, fusiform, not moniliform. Buccal segment distinct, with 2 pairs of tentacular cirri. *Grubeosyllis.*

III.—Palpi small, or rudimentary, or wanting.

E.—Head normal; œsophagus and stomach well-developed. Stem-form of *Autolytus.*

EE.—Head abnormal. Eyes large. Œsophagus and stomach wanting or rudimentary. Capillary setæ usually present. (Sexual zoöids.)

f.—Antennæ and tentacular cirri present. ♀ *Autolytus.*

ff.—Antennæ and tentacular cirri absent. *Tetraglene.*

fff.—Tentacular cirri absent. *Chætosyllis*

Remarks on certain genera of Syllidæ.

Amblyosyllis Grubé *non* Langerhans.

The genus *Amblyosyllis* Grubé (Vidensk. Meddel. Naturhis. For., Kjobenhavn, 1857, p. 186) seems to have been misunderstood by later writers. It seems to be widely different from the genus of that name as defined by Langerhans and adopted by others.

As originally established it included only *A. rhombeata* from St. Croix. It was said to agree with *Syllis* as to its body, parapodia, cirri, and setæ, but the cephalic lobe is coalescent with the buccal segment, and palpi are wanting. "Tentacles 3, tentacular cirri 2, eyes 2." Under the specific description these characters are reaffirmed. The tentacular cirri are again said to be 2 "(utrinque 1)." The setæ are numerous, compound, with long linear blades. The body-segments are few (14). The two eyes are large, oval. The tentacles (antennæ) and cirri are long and imperfectly articulated or "crenulated."

It is, perhaps, the sexual zoöid of some better known genus, but the single pair of tentacular cirri and eyes, and the absence of distinct palpi are characters entirely at variance with the genus *Amblyosyllis* of Langerhans, unless it be arbitrarily assumed that it was very badly described.

The latter is made nearly equivalent to *Pterosyllis* Clap. and nine species were referred to it, besides Grubé's type. As defined, it scarcely differs from *Trypanosyllis*, except in having a long, folded œsophagus. But it has *two pairs* or *three pairs* of eyes; *two pairs* of tentacular cirri; a *distinct* buccal segment; and two *free, separate* palpi, which are usually small and bent down under the head.

To this genus of Langerhans belongs the elegant New England species, *Pterosyllis cincinnata* Ver. (1874, p. 394, and 1881, p. 308). The latter has rather small, but distinct, palpi; six eyes; and very long moniliform cirri.

Until the original species of Grubé can be reexamined, it would appear to be far better to retain *Pterosyllis* for the northern genus, for it is probable that there are still numerous unknown generic types of annelids in the West Indies.

Grubeosyllis V., nom. nov.=**Grubea** Quatr.

The name *Grubea* Quatr., 1865, was preoccupied by *Grubea* Diesing, 1858, a genus of trematode worms. Therefore I propose to substitute for it *Grubeosyllis*. (See the analytical table, p. 632, for the generic characters.)

Several species occur on the U. States east coast; among them are *G. Websteri* V.; *G. maculata* V., sp. nov., which is a stouter species, but similar to the last; has a larger and wider head and larger eyes, and a large buccal segment, on which there are four dark ovate spots; the antennæ and cirri are longer and have a middle band of brown with acuminate, acute tips; and *G. fusca* V., sp. nov., which is distinguished from both by its shorter and wider palpi and head, more swollen and shorter antennæ and cirri, shorter and more elliptical stomach, and by having crowded brown spots on its dorsal surface, becoming fewer in front of the stomach, and by its large anterior eyes.

There are also several Mediterranean and Madeira species, as *G. fusifera* (Quatr.); *G. clavata* (Clap.); *G. dolichopoda* Marentz., also recorded from New Jersey by Webster; *G, pusilla* (Duj.); *G. tenuicirrata* (Clap.); *G. limbata* (Clap.). By Langerhans the first three of these European species are considered identical.

Eusyllis Malmgren.

Under this genus there are now included several diverse groups that agree in having the anterior margin of the œsophagus finely denticulated but differ in their setæ, cirri, palpi, etc.

Eusyllis, typical subgenus.

If we consider as type, the first of the two species of Malmgren (*E. Blomstrandi*), in which the antennæ and cirri are not moniliform and the non-sexual setæ are mostly compound with bidentate blades, the genus would scarcely differ from *Pionosyllis* Malmg., of the same date, except in the serrulation of the œsophagus. *Pionosyllis* was originally separated mainly on account of its capillary setæ, now known to be only a sexual character. It may be said to be a *Syllis* without articulated cirri.

As it is convenient to have a distinctive name for this particular type, I propose to consider it a subgenus, *Eusyllis*, differing from the next group in having the appendages imperfectly articulated. Besides the compound setæ there is an acute simple seta and often a bidentate one in the posterior fascicles. Saccular gular glands are lacking alongside the œsophagus.

The second species described by Malmgren was *E. monilicornis*. It has been redescribed by others and is better known than the first species. Its palpi are separate nearly to their bases; the cirri are

more distinctly articulated; its setæ are partly compound with bidentate tips, as in *Syllis*, and partly simple, with bidentate or forked ends.

Synsyllis, subgen. nov. Type **S. viridula** V.

E. viridula Ver., described above, p. 622, and *E. longigularis* (p. 624), differ from the type chiefly in having posteriorly mostly simple forked setæ or crotchets, like the stem of a compound seta having a short blade consolidated with it; and by having regularly beaded cirri and large, entirely separate palpi, as in *Syllis*.

Langerhans (1879, p. 550) united *E. Blomstrandi* and *E. lamelligera* Mar. and Bobr., which differ so considerably that it seems impossible they can be identical. St. Joseph, op. cit., p. 171, clearly separated them. Malmgren's species is described and figured as having entirely separate palpi, while *E. lamelligera* is represented as having them united for nearly half their length; the latter also has flat, large, differentiated ventral cirri on the first parapodia, and a pair of large saccular gular glands. These characters would indicate a generic difference.

Desmosyllis, gen. nov.

Type *D. tenera* Ver., Brief Cont., 53, p. 368, 1882, (as *Eusyllis*). Two species from our coast—*D. tenera* Ver. and *D. fragilis* (Webs. 1879, as *Syllis*) agree in having the large palpi united for about half their length, and in having long, regularly articulated antennæ and cirri. Most of the setæ are compound with bidentate blades, as in *Syllis*. In *D. longisetosa*, (see page 626) there is also a single, long, needle-like seta in most of the fascicles.

For this group, which I think ought to rank as a distinct genus, I propose the name *Desmosyllis*. To it may belong *D. lamelligera* (Mar. and Bobr.) referred to above, though in the latter the cirri are less strongly articulated. But the partial union of the palpi is a character of much greater importance.

Hemisyllis Ver. See p. 619, above.

The Bermuda species, described above as *Hemisyllis dispar*, also has the palpi half-united, but it has only a few, simple, unequally bidentate or birostrate setæ, all alike, as in *Haplosyllis*. Like the latter, it inhabits sponges.

Marphysa regalis, sp. nov.

A highly iridescent, large, robust species, composed of about 125 to 130 segments, narrowed close to the head. The branchiæ begin at about the 20th segment; becoming trifid at about the 25th or 26th segment, and 4-branched at about the 45th, continuing as a simple cirrus, on a large number of more posterior segments. In the adult some branchiæ are 5-branched.

Head narrowed, with two deeply separated, rounded front lobes. Three median antennæ are about equal, tapered, articulated, with about 5 oblong annuli, not deeply constricted; length about one-half the breadth of the buccal segment; outer antennæ similar, about one-quarter shorter.

The buccal segment is as long dorsally as the next two, or as long as the next three at the sides.

From 18 to 22 anterior setigerous segments are without branchiæ. The first branchiæ are usually bifid in the adult, but simple in immature individuals; bifid branchiæ continue to about the 25th or 26th setigerous segments, where they become trifid, with long, slender, nearly equal branches, and these may continue for a large number of segments, but in the fully adult specimens they become 4-branched on a number of segments back of the 45th, and a few sometimes have 5 cirri. Posteriorly they gradually decrease; being simple on about 40 segments, and wanting on the last 60 segments.

The dorsal cirri on the anterior 20 segments are rather long, thick at base, rapidly tapered or acuminate distally, and faintly annulated; in the branchial region they become smaller and more conical. The first pair of ventral cirri are rather long, equal to the setigerous lobe; a little farther back they became low, broad, verruciform with a small, papilliform terminal joint.

The setæ in the branchiated segments are numerous; in the upper fascicle the longer capillary setæ have rather long and slender acuminate tips; they are accompanied by a number of brush-shaped setæ with wide ends. In the lower fascicle all the setæ are compound, and have rather stout stems, with enlarged sublanceolate ends; blades oblong-lanceolate, the ratios as 1 : 4–5, with the tips strongly bidentate. Each fascicle has a large, black, spiniform aciculum, that of the upper fascicle larger and less acute; their tips project somewhat, as preserved.

Color, in formalin, brownish or flesh-color, mottled with darker, with a brilliant iridescence. The surface, under a lens, appears minutely punctate, and is finely specked with whitish dorsally.

Length, in life, over a foot ($+300^{mm}$).

Breadth of a large but imperfect specimen, in the branchial region (40th segment) is 9^{mm}; of buccal segment, 4^{mm}.

Heteromarphysa, gen. nov.

Body slender; five antennæ (or tentacles) and a pair of separated ventral palpi. Head rounded in front. Eyes 4, well-separated. Buccal segment large, united to the head dorsally, and to the next segment without a visible suture (as preserved). Branchiæ lacking. Setæ of several sorts—compound, capillary, and uncinate; ventral ones in the anterior fascicles, compound. Jaws similar to those of *Paramarphysa.*

Heteromarphysa tenuis, sp. nov.

Slender and rather long, with elongated segments, separated by constrictions, except the first four, which are nearly continuous, (perhaps due to imperfect preservation).

Head about as broad as long, obtusely rounded in front, with a minute median emargination; posterior margin more broadly rounded; widest behind the middle. Eyes 4, small, black, nearly equal, nearly in a square; the anterior ones situated close to the anterior margin; the others, rather farther apart, are behind the outer antennæ. The palpi are rounded, about as long as wide.

The jaws are mostly soft and light colored, but appear to agree closely with those of *Paramarphysa.*

Antennæ very long and slender, tapered, acute, smooth, not articulated, but attached to a large and long base. The inner paired ones are the longest, being about 5 times the breadth of the head; odd one somewhat shorter; outer ones about one-quarter the length of the longest.

The buccal segment is wider than the head and continuous with it.

Two tentacular cirri are present on one specimen; they are very long and slender. The larger specimen has 47 segments, but the posterior end is gone. Another smaller entire one has 38 segments.

The parapodia are longest and largest on the anterior segments, decreasing rapidly, but not abruptly, in length after about the 7th.

The dorsal and ventral cirri are about equal on the anterior six segments, rather long, tapered, enlarged at base and tapered distally. On following segments the dorsal cirri become gradually shorter and thicker, and are nearly obsolete after the 12th, but the ventral cirri become smaller and more slender and continue to the end of the body.

The ventral fascicles, on the anterior 3 segments, have 4 or 5 compound setæ, with strongly curved blades, 4 or 5 times as long as wide, with a strongly incurved bidentate tip. The upper fascicle contains a few small capillary setæ. On the 4th segment there are one or two shorter compound setæ with smaller blades, and a few acute capillary setæ with the shaft thickened and bent distally, and a group of longer and more slender ones in the upper fascicle. Uncinate setæ with the tips bidentate and limbate commence on the 11th segment, where there is only one, but they increase to 2 or 3 farther back, and then decrease to 1 posteriorly. All the setæ are larger and longer on segments 6 to 12; there are also 2 or 3 compound setæ with acute capillary blades on segments 8 to 10.

Color, in formalin, greenish white, with paler, fine, sutural lines and a darker dorsal stripe; an obscure darker spot at the base of each of the parapodia.

Length of the longer imperfect specimen, 11^{mm}; diameter, 6^{mm}.

Flatts Inlet beach, in shell-sand, at low tide; 2 specimens.

Leodice or **Eunice.**

Eunice Cuvier, 1817, *pars*, = *Leodice* Savig., 1820, emend. Malmgren.

The Bermuda species belong to the genus *Leodice*, as restricted by Malmgren, who restricted *Eunice* to the type of *E. gigantea.* The name *Eunice* was in prior use by Hubner for a genus of insects, in 1816, and its use may have to be abandoned for the annelids.

At least 21 nominal species of *Eunice* have been described from the West Indies, Florida, and Bermuda; 3 by Schmarda, 1861; 1 by Baird, 1870; 4 by Œrsted and Grubé, 1879; 2 by Pourtales; 4 by Webster, 1884; 2 by McIntosh, 1885; 5 by Ehlers, 1887. Ehlers* has also redescribed and admirably figured several of the species previously described by Œrsted and Grubé and by Pourtales.

In consequence of the three later works appearing so nearly together, several of the species have received two or three names. The difficulty of identification is, in some cases, much increased by the fact that several of the species which actually grow to large size, have been described from very small and immature specimens, only one or two inches long, and in some cases even these were mere fragments of a single individual, so that no account could be taken of individual variations or of differences due to age.

* Memoirs Mus. Comp. Zoöl., vol. viii, 1887. In this work nine species are included; eight species are very fully described and figured.

Our Bermuda collection contains several common species that grow to the length of 8 to 12 inches or more, which, indeed, seems to be a common size for the species of this genus.

The commonest large reef-species are *L. longisetis* W.; *L. mutilata* W. = *E. barvicensis* McInt.; *L. violaceomaculata* Ehl.; *L. denticulata* W. = *L. filamentosa* (Œrst. and Gr.) = *E. cirrobranchiata* McInt. We did not find *L. longicirrata* (Webst.).

Webster also recorded *E. violacea* Œ. and Gr. from Bermuda, but this large species was described from the Pacific coast of Central America. It has a 4-lobed head and very large pectinate branchiæ, with 20–28 branches. No such species was found by us. Webster gives no description of his examples, therefore it is impossible to tell what he had, without a re-examination of his specimens, but it may have been *L. violaceomaculata* (Ehl.). This is a very large species that is not uncommon. It has a bilobed bead ; the branchiæ are all pectinate and the larger ones have about 20 branches ; the first appear on segments 6 to 9 ; the dorsum is curiously mottled, and there is no white nuchal band.

One of the most abundant species in dead corals is *L. longisetis* (W.) This becomes more than a foot long. In life it is reddish brown or chocolate-brown, curiously marked dorsally with longitudinal, zigzag or reticulated brownish-black lines. The antennæ and long dorsal cirri are conspicuously banded with pale yellow and dark brown, about 6 pale bands on the antennæ and 3 on the dorsal cirri. There is a conspicuous white band on the 3d setigerous segment. The larger branchiæ are pectinate, with 7 to 10 slender graduated cirri ; the first appear on the 4th to 6th segment, usually on the 5th. The head is bilobed in all our numerous specimens, though Webster described it as 4-lobed. His single specimen was probably badly preserved and misleading. It resembles *L. Floridana* (Ehl.) and *L. fucata* (Ehl.), of Florida.

Leodice mutilata (Webs.) = *E. barvicensis* McInt. is another large and abundant species, which lives with the last and is often over a foot long. Like the latter, it has a white nuchal band,—a feature not uncommon in the genus. These two species look much alike, but differ in their jaws and setæ. In *L. mutilata* the gills usually first appear on the 5th to 7th segment, and the largest seldom have more than 6 to 8 cirri, which are long and subequal. The dorsal cirri are much shorter than the branchial cirri, and the antennæ are rather short and not articulated.

Leodice denticulata (Webs.) = *E. cirrobranchiata* McInt. is another large species found among dead corals. Probably *E. filamentosa*

Œrs. and Gr. is the young (14½ lines long) of the same species. *L. conglomerans* (Ehlers) is a fully adult, large form, perhaps the same. Perhaps *L. hamata* (Schmarda) is also the same species.

It is distinguished by having the first simple branchiæ arising on the 23d to 27th segment, and bifid and trifid ones back of about the 45th to 50th segment; the largest branchiæ have usually 4 or 5 cirri, rarely 6; simple branchiæ extend to very near the end of the body. The antennæ are nearly smooth or feebly articulated, according to the state of preservation, and the enlarged distal part of the stem of the compound setæ is denticulated on one side. The segments are very short and numerous (over 300 in examples 250^{mm} long), and usually finely specked with white on the back.

Leodice binominata (Quatr.) = **E. punctata** Œrs. and Gr.

This is a smaller (150^{mm} long) and much rarer species, not before recorded from Bermuda. Its antennæ and cirri are long and delicately beaded, and it has branchiæ only on about 30 segments, beginning on the 4th or 5th. The larger ones are gracefully pectinate with about 10–12 cirri and they meet over the back. In life it is usually pale green, but reddish anteriorly, and finely specked with white dorsally, and with a median row of white spots, one to a segment; the cirriferous buccal ring is also white. The row of white spots persists a long time in formalin. *L. rubra* (Œ. & G.) is much like this, but has branchiæ on nearly all the segments.

Leodice elegans, sp. nov.

Head deeply bilobed, narrow. Body slender, with about 155 segments, flattened posteriorly. Notable for the anterior position of the branched gills.

Antennæ long and very slender, scarcely tapered, well articulated; about 10 distal annuli, most distinct on the longer ones, and mostly elliptical; the inner paired antennæ reach back to the 3d body segment; outer ones about equal to the long buccal segment (median is broken in the type). Eyes large, black, with a lens. Tentacular cirri slender, tapered, rather longer than the buccal segment, with about 8 short annuli. Parapodia prominent; dorsal cirrus rather long, tapered, acuminate distally, and annulated, with about three divisions.

Branchiæ are mostly gracefully pectinate; they begin with 2 slender branches on the 2d setigerous segment; they have 3 branches on the 3d, and become pectinate, with 4 or 5 branches, on the 4th; a little farther back they become 9-branched, with the branches slen-

der and graduated. On the posterior branchial segments there are three pairs of gills with 4 branches; 3 with 3; 2 with 2; and 1 with 1 cirrus. They end at about the end of the anterior third of the body, or near the 30th segment, leaving about 125 segments without any. Ventral cirrus anteriorly is long and tapered; on the 1st segment about equal to the dorsal cirrus. Upper caudal cirri long and slender, about like the tentacular cirri; lower ones short.

Capillary setæ are long and slender with fine long tips; brush-shaped setæ are few, with elongated marginal processes and about 6 intermediate fine denticles and striæ. Acicula 2, yellow, spiniform, hardly acute, unequal, about twice as thick as the compound setæ; the latter are short, their blades have ratios of breadth to length of 1:4–1:6, limbate, tip only slightly incurved, with a tooth below it, standing nearly at a right angle; another small tooth stands near the base; the edge of the limbus is finely serrulate, as is the inner distal margin of the head of the shaft.

Length, about 100^{mm} (mutilated posteriorly); breadth, 2^{mm} to 2.5^{mm}.

Only one specimen was found.

Leodice stigmatura, sp. nov.

A long, slender species with long, very slender, partially or distally annulated antennæ and tentacular cirri; long slender dorsal cirri; digitate branchiæ, the larger with three to five slender cirri, and bifid or simple branchial cirri present to about the 100th segment. Caudal region with two or four rows of distinct, round blackish spots.

Head with two lobes, separated but little by the frontal notch; each lobe is usually very obscurely divided by a slight transverse indentation into an upper and lower half (head quasi-4-lobed). Eyes rather large, black; median antenna very long and slender, scarcely tapered; the basal half obscurely divided by shallow grooves into rather short joints, but the distal part has more evident and longer articulations, the distal six joints forming about half its length; it extends back in some specimens to the 15th setigerous segment, but more often about to the 5th, varying according to the degree of contraction of the segments; it is about five times as long as the head; inner paired antennæ similar, but somewhat shorter, reaching in some cases the 10th segment, in others to the 3d. Outer antennæ about one-quarter as long as the median, more distinctly annulated, with about 10 annuli, the distal four forming half the

length, long-elliptical, or sausage-shaped. Tentacular cirri long, slender, tapered, acute, feebly articulated, about equal to the buccal segment and head, and decidedly longer than the outer antennæ. Parapodia rather prominent and the segments rather deeply constricted. Dorsal cirri long and slender, tapered; the anterior ones usually longer than the longest branchial cirri, and about equal to the length of four body-segments.

Branchiæ begin as simple cirri on the third segment; become trifid at about the 7th; 4-branched from about the 10th–14th to the 37th, and then decrease gradually, bifid and simple ones extending nearly to the end, usually ceasing about on segments 100 to 105, leaving about 40 bare, in specimens of average size. In the large examples some of the larger branchiæ may have five cirri; their cirri are long and slender, mostly subequal, arising from short stems, so that the gill is digitate rather than pectinate; the larger ones meet across the back.

The posterior and middle parapodia contain usually one or two spiniform acicula and a rather smaller, oblique, recurved uncinate one, which has a slightly bidentate tip, with two small scarcely hooked terminal denticles, below which the inner edge bears a much larger, rather wide, triangular tooth, standing at about right angles to the shaft; the end is broadly limbate. The compound setæ have rather long and narrow bidentate blades, the terminal hook being narrow and but little incurved, the other a little removed and divergent, so that the interspace is concave; the edge of the limbus and the terminal inner edge of the shaft are finely denticulate, as in *L. elegans*. The uncinate acicula frequently appear to have the tip narrowly truncate, owing, perhaps, to the wearing away of the two distal denticles, which are always smaller and less hooked than those of *L. binominata*.

The color in life is milk-white or translucent white, often with two submedian and two lateral rows of small, round, blackish spots; the lateral spots are at the bases of the gills and occur in several other species; the other spots are often conspicuous, but are sometimes wanting in the ripe females, which have the whole posterior part of the body filled with large white eggs. The intestine usually shows as a broad, irregular brownish band, and the dorsal blood-vessel as a narrow red line.

Length of ordinary specimens, in life, 75 to 100^{mm}; breadth, 1–2^{mm}; in formalin the length is usually about 60^{mm}. A few females, filled with eggs, are considerably larger,—about 100^{mm} long in formalin.

Not uncommon in dead corals on the reefs. A few specimens were found in tubes attached to the under side of stones at low tide. The tube is thin, parchment-like and coated with small fragments of shells. It secretes a large amount of mucus when disturbed.

Leodice concinna, sp. nov.

Head slightly bilobed, with a very shallow frontal notch. Eyes moderately large, black. Antennæ all strongly beaded, of moderate length. The median one reaches about to the second setigerous segment; outer lateral ones about one-third as long; inner laterals similar to the median one and nearly as long.

Buccal segment, with the cirriferous ring, is about equal to the next two segments. Tentacular cirri are about as long as the buccal segment, small, tapered.

Body-segments are numerous, short, but little constricted. Parapodia only little prominent, especially back of the branchial region. Dorsal cirri rather small, tapered, of moderate length.

Branchiæ are palmate or digitate, rather than pinnate; the first appear as small simple cirri on the third setigerous segment; 3-branched ones on the 7th; 4-branched ones on the 8th; none with five cirri were observed. They cease on the 52d segment, the last 10 being simple and short.

The setæ are much like those of *L. stigmatura*.

Found in dead corals from the reefs.

This resembles *L. stigmatura*, but the latter has many more branchiæ, longer antennæ and cirri, and more constricted and much longer segments.

Leodice tenuicirrata, sp. nov.

A small species with remarkably long dorsal cirri. Head very obscurely 4-lobed; the frontal lobes are rounded, but have a slight horizontal indentation on the outer side. The antennæ are long, slender and articulated; the median one is about four times as long as the breadth of the buccal segment; the inner lateral are lost from the type; the outer laterals are about half as long as the median, a little stouter and more tapered, and with many short annuli, in length equal to about $1\frac{1}{4}$ times the breadth of the buccal segment.

Tentacular cirri very slender, acute, nearly as long as the median antennæ. Dorsal cirri very long and slender, nearly as long as the tentacular cirri, are nearly equal to the breadth of the body, much longer than the branchial cirri; they stand out at right angles to the body so that they are conspicuous.

Branchiæ begin as simple cirri on the 3d setigerous segment; they have 2 cirri on the 6th; 3 on the 8th; 4 on a few segments farther back. On the 46th, which is the last segment preserved, they have two cirri. From dead corals; only one example.

The setæ resemble those of *L. binominata* and *L. stigmatura*. It is allied to *L. articulata* (Ehl.) and to *L. ornata* (Andrews).

Leodice unifrons, sp. nov.

A small slender species. Head undivided, rounded in front, without any frontal emargination, the outlines nearly semicircular. Eyes rather large, black. Antennæ articulated, with the annuli unequal, the distal ones elliptical, twice as long as wide, and very distinct; the median antenna is rather longer than the head and buccal segment; the inner laterals are a little shorter; the outer laterals about half as long as the median. Tentacular cirri are obscurely annulated, slender, about equal to the length of the buccal segment. The dorsal cirri are long, equal to the longest branchial cirri.

The branchiæ begin as simple cirri on the 3d setigerous segment; two branched ones appear at about the 8th segment; the largest are pectinate, with five or six long, slender, subequal cirri on the 16–23d; trifid on the 34th; simple branchiæ continue nearly or quite to the posterior end of the imperfect specimen, which has 43 segments.

In life the color is pale brown with a median dorsal row of white spots, one to a segment, and with olive-brown irregular mottlings on each side; antennæ pale, translucent, banded with flake-white.

The only specimen found had lost the posterior segments. It was about $1\frac{1}{2}^{mm}$ in diameter, in life, and $60–70^{mm}$ long.

Flatts Inlet, in shell-sand at low-tide.

Leodice margaritacea, sp. nov.

A small long and very slender species, nearly white, with a pearly iridescence. Antennæ slender, distinctly annulated; gills short pectinate; anterior parapodia prominent; posterior ones small. Head slightly bilobed; eyes rather large. Antennæ very slender, rather long; the median reaching back to the 2d or 3d setigerous segment; inner laterals a little shorter; outer laterals about $\frac{1}{2}$ as long as the inner. All are unusually slender, scarcely tapered, very distinctly annulated distally, the joints being constricted and the divisions longer than broad. Tentacular cirri slender, tapered, acute, reaching about to the front edge of the buccal segment. The 1st buccal segment and cirriferous ring together are about equal to the

next two segments and longer than the head. The parapodia on the anterior half of the body are rather long and prominent, with long capillary setæ, but back of the branchial region they become small and but little elevated, with a minute papilliform dorsal cirrus.

The larger branchiæ have 4 or 5 long slender cirri ; they begin on the 3d or 4th segment with two small cirri, and increase to 3 cirri on the 8th and to 4 at about the 14th ; those from the 24th to 28th often have 5 cirri. They begin to rapidly decrease at about the 30th and cease at about the 45th to 50th segment.

The capillary setæ anteriorly are 3 or 4, not very long, becoming 4 to 6 and longer, farther back ; compound setæ are about 6 anteriorly, and 4 posteriorly ; the uncinate setæ are strongly recurved at the neck ; the end is tridentate, the tip is divided into two small slightly incurved denticles, and the hook on the inside is sharply angular, longer than the terminal part.

The color in formalin is pearly white and iridescent, sometimes with slight darker bands or rows of spots across the anterior segments and with dusky annulations on the antennæ.

Length, 35 to 50^{mm} ; diameter, 1.5^{mm}.

Flatt's Inlet, low-tide to 10 feet, in shell sand, common.

Lysidice bilobata, sp. nov.

The head has two evenly rounded lobes in front, separated by a deep notch. The buccal segment is twice as long as the next, and about equal to the head. The three antennæ are about equal, and about as long as the head, scarcely tapered, blunt. The eyes are small, black.

The parapodia are small with papilliform dorsal and ventral cirri. On the anterior segments, the compound setæ are about 6, with stout distal enlargements and small, short blades, minutely bidentate at the extreme tip, and with a tooth on the inside edge, near the base. The capillary setæ are much longer, usually 4 or 5, considerably bent and flattened, with a long acuminate tip. The 2 or 3 brush-shaped setæ are rather small, and the rapidly enlarged end has about 10 slender denticles, the marginal ones only slightly longer. There is one, or sometimes two, black spiniform acicula and a black uncinate seta of about the same size, having the end slightly bifid and a little bent, but not limbate ; the bidentation is at the extreme tip ; the lateral tooth is slightly the larger and is directed obliquely distally.

Posteriorly the setæ are nearly the same, but the uncinate seta is more strongly bidentate.

Color in formalin, plain yellowish white and strongly iridescent. The largest specimen is a female filled with large white eggs. It has lost its posterior segments. The anterior portion, with 30 setigerous segments, is 9^{mm} long; 2^{mm} broad; young ones of 80 segments are 16^{mm} long.

Paramarphysa obtusa, sp. nov.

Long and slender, widest anteriorly, attenuated posteriorly, with rather prominent parapodia and long setæ in the anterior region, and much smaller ones posteriorly. Head $\frac{1}{3}$ broader than long, evenly obtusely rounded in front, with a faint median furrow, or slightly bilobed in front, according to the mode of preservation.

Antennæ smooth, rather short, the three median subequal, often fusiform and slightly tapered distally, or slightly clavate and obtuse; the median one is about twice the length of the head; inner laterals scarcely $\frac{1}{5}$ shorter; outer laterals $\frac{1}{4}$ shorter. Eyes large, black, reniform. Buccal segment rather longer than head, scarcely distinct from the next. Dorsal cirri rather short, tapered, the first very small.

The posterior third becomes very slender, with rather long and almost moniliform segments and small parapodia, with conspicuous black acicula. Caudal cirri small, about as long at the diameter of the anal segment; median cirrus minute papilliform.

The 1st buccal segment is nearly as long as the head, and $\frac{1}{3}$ longer than the second segment.

The 2d buccal segment is rather closely united with the first and with the succeeding 1st setigerous segment, with shallow constrictions, but farther back, the segments are convex with well-defined constrictions between them. The 1st pair of parapodia are small and only slightly prominent, with few and short setæ, and a small papilliform dorsal cirrus, smaller than the ventral, but they rapidly increase in size and prominence, in the thoracic region. Posteriorly they again become small, with papilliform cirri. The jaws are well developed but mostly pale horn-color.

Capillary setæ 4–6 anteriorly, 2–4 posteriorly, flattened distally, with long, slender pointed tips. Compound setæ 6–8 anteriorly rather large with short blades, minutely bidentate at the extreme tip, not incurved. Uncinate seta of the middle and posterior regions, large, black, strongly curved distally, at the neck, and with

a large angular hook, stouter than the acute terminal denticle; absent anteriorly. Aciculum posteriorly large, black, spiniform, subacute; paler and more slender anteriorly.

Color, in formalin, white. Length, 25–35^{mm}; diameter, 1–1.25^{mm}.

Flatt's Inlet, at low-tide, in shell-sand. Several specimens.

P. longula Ehl. differs from this in having a distinctly bilobed head; much longer antennæ, straighter and less hooked uncinate setæ, fewer and more slender capillary setæ, longer and more strongly bidentate blades to the compound setæ, and shorter jaws.

Nematonereis hebes, sp. nov.

Body long, slender, terete, with rather long, and posteriorly with only slightly constricted segments; often coiled in a spiral. Head broadly rounded in front, nearly hemispherical, rather broader than long. Eyes small, black. Antennæ fusiform, swollen above the constricted base and gradually tapered to the acute tip, nearly as long as the head. First buccal segment about as long as the head, the second about half as long and about equal to the next. The divisions between the two buccal rings and several following segments is very slight. Dorsal cirri on the 1st segment are small, papilliform; on succeeding segments they are longer and tapered, the longest about $\frac{1}{3}$ as long as the breadth of the body. The longest anterior parapodia are quite prominent, with a short, thick ventral cirrus, with a swollen base, a large setigerous lobe, and a long dorsal cirrus. There are 2 or 3 long, slender, slightly flattened capillary setæ; a few compound setæ with narrow, feebly bidentate blades; a slender, yellow, spiniform aciculum, and farther back an uncinate seta with a strongly recurved neck and a strongly bidentate tip; the hooked lateral tooth is larger than the acute terminal one, and angular, much as in *Paramarphysa obtusa.* Color, in formalin, pale greenish white.

Length, 25–30^{mm}, in formalin; diameter, about .3^{mm}. Three specimens.

Stauronereis, nom. nov.=*Anisoceras* and *Staurocephalus* Gr. (preoc.)

Type *Staurocephalus Rudolphii* (D. Ch.) Ehlers, Borstenw., p. 434, pl. xviii, figs. 17–26.

Anisoceras Grubé, Vid. Meddel., p. 60, 1856 (*non* Pictet, Cephal., 1854).

Staurocephalus Grubé, Zeitsch. fur Wiss. Zool., 1855, p. 97 (*non* Barr., Crust., 1846).

The name *Staurocephalus* must be dropped, because clearly preoccupied in Crustacea, 1846. *Anisoceras,* which Grubé originally considered a distinct genus, but which Ehlers and others have

regarded as only a subgenus, with longer antennæ, cannot be used for the genus, because it and its variants had been used in at least four or five other senses before it was applied to these annelids. *Anisoceras* was used by Pictet in 1854; *Anisocera* was used in Coleoptera, both in 1833 and 1835; *Anisocerus* was used in Coleoptera, both in 1835 and in 1837. *Prionognathus*, Kef., 1862 (*non* LaF., 1851, *nec* Pand., 1856) is a closely related group, but the type *S. ciliata* (Kef.) may, perhaps, be a distinct subgenus.

Another group, perhaps of generic value, is typified by *S. rubrovittata* (D. Ch.) well described and figured by Ehlers (Borstenw., p. 424, pl. xviii, figs. 1–16), which was the type of *Staurocephalus* Gr. It has a prominent, long, pyriform head with large, flat, recurved, frontal palpi; much shorter articulated antennæ; 4 eyes; a conspicuous ciliated lobe on each side of the neck; a terminal article on the dorsal cirri; stout nearly parallel lower jaws, ending abruptly anteriorly, and with acute, mostly strongly dentate plates in two or three series forming the upper jaws. For this group, I would propose the subgeneric name *Teleonereis*.

If it be thought necessary to change the name of the family owing to the change in the principal genus, I would propose to adopt *Stauronereidæ*, as it is analogous to *Lumbrinereidæ*.

The following three Bermuda species belong to the group called *Anisoceras* by Ehlers, for they have long articulated antennæ. The same is true of *Stauronereis pallidus* (V. 1873), of the New England coast; *S. sociabilis* (W. 1878) of Virginia; *S. cœcus* (W. 1884), of New England; and several European species, including *Stauronereis Rudolphii* (D. Ch.) so well described by Ehlers, and *S. Chiajei* (Clap.) of the Mediterranean; *S. rubra* (Gr.) St. Croix; *S. vittata* (Gr.) and *S. bioculata* (Gr.) from the west coast of Costa Rica.

S. (*Stauroceps*) *eruciformis* (Malmgren). This Arctic species may be the type of a special subgenus, *Stauroceps*. It has a small head with very short non-articulated antennæ and smooth dorsal cirri, without a terminal article. Its jaws, as figured, also appear to be more simple than those of most of the other described species. *S. minimus* (Langerh., 1884) of Madeira has even less developed antennæ and cirri, though it must be immature. Perhaps it belongs rather to *Paractius*.

Stauronereis melanops, sp. nov.

Head rounded in front and behind, with the sides a little prominent, about as long as broad; a pair of divergent, narrow-lanceolate ridges arises from the middle of the posterior margin.

Eyes round, black, with lens, the anterior ones much the larger, situated at the anterior bases of the antennæ and as broad as the antennæ, or a little broader; posterior eyes about half as large and nearer together, thus forming a trapeze. Antennæ longer than the palpi, tapered, distinctly annulated, with 13 articles. The articles near the base are short; distally they become much longer and more separated, the last two being 4 or 5 times broader than long, and these two joints project beyond the tips of the palpi. The palpi are stouter than the antennæ, curved, tapered, crenulated on the outer edge, and slightly annulated distally.

Dorsal cirri are biarticulate, rather long and slender, the basal article longer and about equal to the setigerous lobe on anterior part of body, while the distal article is more slender, tapered, acute. Posteriorly the basal article becomes longer and more slender, exceeding the setigerous lobes, and the distal joint also becomes longer, nearly as long as the basal, with a slender acute tip.

Setæ are long and numerous, the capillary ones are slender and straight, a little longer than the compound ones, which have a narrow blade, 5 to 8 times longer than wide, with strongly bidentate tips.

The lower jaws are strong, black, both ends strongly bent back like a short bow, the posterior end blunt; the anterior prolonged by a series of 4 small separate pieces; the upper jaws are elongated, little bent, divided into about 20 denticulated plates, with very acute, long, incurved denticles in the under series, anteriorly.

None of the specimens have the caudal segments; the longest is 10^{mm} long, 2^{mm} broad, and has 38 setigerous segments.

Stauronereis erythrops, sp. nov.

Head broadly rounded in front, a little produced posteriorly, longer than broad. Eyes yellowish-brown, arranged in a trapeze, and much smaller than in the preceding species, the anterior about twice as large as the posterior, all with a lens. The antennæ and palpi are short and about equal, in length less than breadth of head; the palpi are stouter than the antennæ; the latter are annulated. The dorsal cirri are much shorter than in the preceding species; the basal article is thick, the terminal is small, ovate or elliptical; the total length about the same as the setigerous lobe, or a little more, anteriorly, but posteriorly both articles become longer and the cirri considerably exceed the setigerous lobes. The compound setæ have rather short bidentate blades; their length 3 to 5 times their breadth.

The lower jaws are rather less bent than in the preceding species, with the posterior ends more incurved and acute. The upper jaws, which have about 16 plates in each series, are stronger and more bent in the middle, the anterior plates having the denticles shorter than those farther back and less claw-like than in the last species. The two middle denticles are much the larger.

The only specimen (probably young) has 55 setigerous segments; length, 7^{mm}; breadth, 1^{mm}.

These two species appear to be quite distinct from *S. pallida* Ver., 1873 (*non* Langerhans, 1879),* and other species of the United States coast, and from *S. rubra* (Œrst. and Grubé), as *Anisoceras* (1854) of St. Croix, the only related species described from the West Indian region.†

In both of our species the lower series of plates of the upper jaws terminate posteriorly in a rather short, irregularly oblong plate, without denticles, while the denticles increase in length on the other plates, anteriorly. Thus the structure is quite unlike that of the jaws in *S. rubrovittata* figured by Ehlers, but more like that of *S. Rudolphii*. The under jaws, especially, resemble those of the latter in form and in having a divergent series of small plates in line with the acute anterior ends, while those of *S. rubrovittata* are much stouter, straighter, and have obtuse anterior ends.

It is possible that these two Bermuda forms may be male and female of one species, but our specimens appear to be immature and the sex cannot be determined. Should this be the case, the name *melanops* would be preferred.

Stauronereis polydonta, sp. nov.

A third species has much longer upper jaws, with about 35–40 plates in each row, gradually decreasing to the minute anterior ones.

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* For the species named *S. pallidus* by Langerhans, 1879, I propose the name *Stauronereis Maderiæ*. It is very different from our New England species.

† The curious free-swimming, gregarious species recently admirably described and illustrated by A. G. Mayer (Bull. Mus. Comp. Zoöl., xxvi, No. 1, with 3 plates, 1900) as *Staurocephalus gregarieus*, does not really belong to that genus, but is the type of a new genus for which I propose the name *Mayeria*.

This genus is characterized by the presence of a single pair of unsegmented organs (palpi) on the front of the head, and by the unsegmented dorsal cirri. The type is without antennæ and eyes. The jaws, also, differ considerably from those of typical *Staurocephalus*.

Mayeria gregarica, the type species, was found swimming at the surface off the Tortugas, Fla., in vast numbers nearly at the last quarter of the moon, from July 1 to July 10, for breeding purposes. This species will almost certainly be found to occur off the Bermudas, at about the same date.

The compound setæ have very long, straight, minutely bidentate blades. Segments, 44 + ; length, 16^{mm}.

Lumbrinereis nasuta, sp. nov.

A long, brilliantly iridescent species. Head (cephalic lobe), in life, much elongated and subacute in extension, the length about twice the breadth, considerably flattened, changeable in shape, sometimes subacute ; no eyes. Buccal segment about half as long as the head. Parapodia small, setigerous lobe swollen ; cirrus small, blunt, papilliform. Setæ of middle and anterior segments are 3 or 4 long uncinate ones, with 2 spiniform acicula that do not project. The uncini bend back distally, at the narrowed neck, with an enlarged truncate head, terminated by two small strongly incurved apical hooks, and with a large, stout, blunt ventral hook. The neck and head have a curious miniature resemblance to those of a horse.

Color, in life, bright light red or purplish and highly iridescent ; parapodia paler or whitish. In formalin, purplish-brown. Posteriorly there is often a single, somewhat bent, acutely acuminate and limbate capillary seta.

Length, in life, 150 to 200^{mm} (about 6 to 8 inches) ; diameter 1 to 1.5^{mm}.

Flatts Inlet, in shell-sand at low-tide.

Arabella maculosa, sp. nov.

In life, very long and slender, only slightly iridescent. Head, in extension, long-conic, somewhat blunt ; ocelli 4, outer ones larger and slightly farther forward. Buccal segment elongated. Parapodia small, with a papilliform lobe.

Body, in life, pale orange-yellow. Most of the segments have 8 to 10 small, transverse, dark olive-green dorsal spots ; 2 of these are median, near the proximal and distal margins ; 2 others may occur on each side proximally ; a row of 4 smaller ones crosses the middle ; a pair of small white spots occurs near the distal edge. Parapodia pale. Posteriorly these markings disappear gradually. Length, in life, 150 to 200^{mm} ; diameter about 1^{mm}.

Flatts Inlet, low-tide, in shell-sand.

Aricia setosa, sp. nov.

Body widest and considerably flattened near the anterior end, gradually becoming smaller and narrowed posteriorly, with the under

side rounded and the back flat and nearly concealed by the prominent cirri and branchiæ. Anterior segments near the head rapidly decrease in breadth. Head small, flattened, widest near the front end, which is truncate or slightly emarginate; sides rounded. Two small blackish spots, like imperfect ocelli, are situated near its posterior border.

The branchiæ begin on the 6th setigerous segment, rapidly become of full size, when they are elongated, tapered, acute ligulæ, as long as the dorsal cirrus, but not quite so broad proximally. They continue nearly or quite to the end of the body.

The first two or three parapodia are quite small, but they rapidly increase to about the 10th. The lower division consists, on the anterior segments, of a torus filled with a crowded group of capillary setæ ; and a foliaceous lobe, prolonged above into a small papilliform cirrus. The tori increase rapidly to the 10th segment and continue of about full size to about the 20th and then rapidly decrease to the 25th, when they become very small, and beyond this, at about the 30th, they are replaced by a papilliform lobe and a cluster of longer capillary setæ and 4 or 5 larger spiniform ones.

The upper parapodium, anteriorly, consists of a broad flat lobe, prolonged at the dorsal angle into a small acuminate cirrus; at about the 25th–30th segment they change rapidly to a longer and narrower falcate cirrus, with a constricted base, above which they rapidly expand, on the outside, to a broad flat portion, beyond which they taper gradually to the subacute tip; they are concave on the dorsal side and are recurved over the back, like the branchial cirri, which they equal in length. These cirri, at about the 35th segment, are more than three times as long as broad, and about twice as long as the ovate ventral lobe, though not much wider.

The numerous crowded setæ of the anterior ventral toriform lobes are much alike, in the form of short, acute capillary setæ, with rather stout shafts. The capillary setæ of the upper fascicle are much longer and far more slender.

On a parapodium from the 32d segment there are 12–16 long, very slender capillary setæ, with attenuated tips, as long as the dorsal cirrus, and about 4 moderately large, straight, acute spiniform setæ, not half as long; in the lower fascicle there are about 18 shorter capillary setæ of the same kind, rather longer than the ventral lobe, and three slightly bent spiniform setæ.

On the posterior segments the setæ are similar, but fewer, about 10 to 12 long ones in the upper fascicle, and 6 to 8 in the lower, with

3 spiniform ones, a little more bent distally. The branchiæ are more slender and longer than the dorsal cirri.

In life pale red; each segment has two narrow, transverse, parallel, orange vittæ, not extending entirely across, and a roundish spot of the same color on each side at the bases of the dorsal cirri. There is a dark irregular spot close to front edge of the head.

Length, in life, 200^{mm}; breadth, 3 to 3.5^{mm}.

Flatts Inlet beach in shell-sand at low tide.

This species is evidently related to *A. platycephala* McInt. (Chall. Voy.), also from Bermuda, but the latter species has gills only on segments 8–18, and the setæ and cirri are different in form.

Cirratulus (Audouinia) capillaris, sp. nov.

A small species with very long slender cirri. Head short, somewhat depressed, bluntly rounded in front, confluent with the buccal segment; the next two segments are hardly distinguishable, except below, and thicker than those that follow, which are subequal, but increase in length posteriorly and decrease in diameter, some being as long as broad; the posterior ones become small, short and crowded.

Setæ and cirri begin together on the 2d body segment; the first cirrus is smaller than the others; the longest are on 2 to 6 following segments, but continue long on 8 or 9 more; shorter ones occur irregularly on more or less of the other segments of the anterior half of the body, but rarely on the posterior half; the length of these is scarcely greater than the diameter of the body.

A transverse group of longer and distinctly larger cirri or tentacles occurs on the 4th setigerous segment, arising from the dorsal surface, about 3 on each side.

The setæ of the anterior 6 or 7 segments, both dorsal and ventral, are very slender, capillary, acute, in small fascicles; they are about equal to $\frac{1}{2}$ the diameter of the body. Spiniform setæ, bent in a sigmoid curve, begin to replace the capillary ones in the ventral fascicles on the 8th segment, and increase in number farther back, till they nearly or quite replace the slender setæ. In the upper fascicles longer, more slender, nearly straight spines gradually replace the capillary setæ, but one or two of the latter persist nearly or quite to the end of the body. Posteriorly there are usually, in the upper fascicles, 2 or 3 spines and 1 or 2 capillary setæ; in the lower ones, about 3 curved spines, larger than the anterior ones.

Cirratulus (Audouinia) Websteri V., nom. nov.

Cirratulus tenuis Webst., Bull. U. S. Nat. Mus., No. 25, p. 323, pl. xi, figs. 56, 57, 1884 (*non* Verrill, Rep. Inv. Vin. Sd., 1873).

This Bermuda species is quite distinct from *A. capillaris*, which seems to be more nearly allied to *A. punctata* (Œrst. & Gr.), from St. Croix. The latter is said to have an interrupted row of cirri on the 5th segment, and differs in other ways.

C. assimilis McInt., which we also obtained at Bermuda, has two oblique series of eyes and larger branchial cirri.

Euclymene V., nom. nov. Type, *Clymene Œrstedii* Clap.

Clymene Savig., 1817 (*non* Oken, Moll., 1815).

The name *Clymene* having been preoccupied by Oken, I propose to substitute *Euclymene* for it.

As here understood, it would include as a subgenus, *Praxillella* Ver., 1882, type *P. gracilis* (Sars) = *Praxilla, pars*, Mgn., 1865 (*non* Reich., 1853). But if the latter cannot well be distinguished as a subgeneric group, then *Praxillella* should include the entire genus as being the earliest tenable name. The extended genus is characterized by the limbate head; funnel-shaped anal segment, bordered by numerous papillæ; and especially by having on about three anterior setigerous segments, one or two stout, bent spines, replacing the rostrate uncini of the ventral parapodia. The setæ are mostly bilimbate, but there are generally, if not always, some smaller pennate setæ, especially in the first three fascicles. The uncini have three to five apical hooks in one row.

The typical forms seem to lack a distinct, free thoracic collar, but some aberrant deep-water forms, that have been referred here, have a collar. They seem to represent new genera.*

**Clymenopsis* V. Type *C. cingulata* (Ehl.) Florida Annel., Blake Exp., p. 185, pl. xlviii. This is characterized by the presence of a large collar on the 4th segment, most prominent beneath. The head is gibbous, with a very narrow limbus, and confluent with the buccal and following three segments. Uncini and anterior spines are as in *Euclymene*. Setæ bilimbate. Anal segment unknown.

Clymenura V. Type *C. cirrata* (Ehl.) op. cit., p. 182, pl. xlvi, figs. 10-13. Head as in *Euclymene*. Anal segment elongated, with a circular rim, bearing 4 long cirri. Uncini remarkable for having, above the large tooth, two transverse rows of numerous small hooklets, the first row containing about 9 larger ones, the 2d many more. The 2d, 3d and 4th setigerous segments are elongated, and each has a narrow anterior collar.

The number of setigerous segments is variable (18 to 70), but is usually from 18 to 22.

Subgenus *Euclymene* (typical) has 17 to 24 setigerous segments, of which the three anterior have one to three ventral spines, and one, two, or three preanal segments, without setæ.

E. zonalis V.=*Praxilla zonalis* V., 1874, is the only New England species.

Subgenus *Praxillella* has the same variation in the number of setigerous segments, but has 4 or 5 achætous preanal segments. *E.* (*Praxillella*) *gracilis* occurs off the northern coast of New England.

Among European species of *Euclymene*, besides the type, *E. Œrstedii* (Clap.); *E. palermitana* (Gr.); *E. planiceps* (Sars), 1871; *E. digitata* (Grubé), belong to this group. But *E.* (*Praxillella*) *lumbricoides* (Grubé); *E.* (*Praxillella*) *simplex* (Clap.); *E.* (*Praxillella*) *collaris* (Clap.); *E.* (*P.*) *gracilis* (Sars); *E.* (*P.*) *quadrilobata*, have the characters of the subgenus *Praxillella*.

A very aberrant species from near Vineyard Sound, Mass. (*E. elongata* (Lewis), as *Clymene*, Proc. Boston Soc. Nat. Hist., xxviii, p. 111, pl. 1, 2, 1897), has a remarkably large number of segments, about 70 according to the excellent description and figures given by Miss Lewis, to whom I am indebted for a specimen. In other respects it does not differ much from the more typical species. But the remarkable increase in the number of segments, so unusual in this family, seems to be a matter of sufficient importance on which to base a subgeneric group, which I propose to call *Macroclymene*, with *E.* (*M.*) *producta* (Lewis) as the type.

The principal characters of this group are the presence of a single preanal non-setigerous segment and of more than 50 setigerous segments, the increase being in the postabdominal region. As in the typical group, there are both bipennate and bilimbate setæ, and the rostrate uncini are of the usual form.

Euclymene coronata, sp. nov.

A large, stout species, none of the examples entire. Head short, thick, with distinct transverse and oblique lateral grooves; median ridge narrow, prominent, with a short obtuse tip; marginal lateral lobes rather wide, erect, with a slight lateral notch, above which the dorsal margin is divided into 8 or 10 small obtuse lobes or denticles.

First three setigerous segments (as contracted) are short, subequal, with a single (sometimes 2), stout, acute, slightly bent, yellow ventral

setæ, and a small fascicle (12 to 15 on the 3d segment) of long, very acute dorsal setæ; the 4th and 5th segments are rather longer, with long series of strong, bent, yellow, bearded uncini (about 30 on the 4th segment); 6th to 8th segments longer; 9th much longer, usually constricted behind the tori; 10th to 15th and following segments are very long, narrowed anteriorly, and have prominent posterior tori. Anal segment funnel-shaped, the border surrounded by 30 or more subequal slender papillæ.

The capillary setæ are of three kinds. Usually there are 6 to 8 longer and larger, rather strong, smooth, very narrowly bilimbate ones, ending in long, slender, flat, flexuous, minutely denticulate tips, and 4–6 shorter and much more slender ones, with fine capillary tips, not limbate; with these there are a few very slender, bipennate setæ, slightly flattened and widened distally, and finely spinulose to the acute tips, the spinules projecting considerably.

The uncini of the middle region are stout and bent back strongly, with a large, sharp, somewhat incurved rostral hook, and 4 small, graduated, appressed apical hooks, of which the 4th is very minute; apex and sides are strongly striated distally. The beard is long and curved strongly backward, it arises from just under the rostrate hook and contains but few fibers. The bulb of the stem is well developed.

Color, in life, bright red, more or less distinctly banded with bluish at the posterior end of most of the segments; posterior half of many segments bright red; 4th with a definite bright red ring.

Length, in life, over 150^{mm}; diameter, 4–5^{mm}.

Found at Castle Island at low-tide, in shell-sand.

Clymenella Verrill, 1873. (Sens ext.)

Axiothea Malmgren, 1865, type *A. catenata;* (*non* Pasc., Coleop., 1864).

Clymenella Verrill, 1873. Rep. on Invert. of Vineyard Sound, etc., pp. 49, 314, pl. xiv, and Annual Rep. U. S. Com. Fish and Fisheries, 1874, pp. 343, 608, pl. xiv, figs. 71–73. Type, *C. torquata* (Leidy).

The genus *Clymenella* originally had for its special character, to distinguish it from *Axiothea*, the presence of an evident collar, with a wide, free anterior edge, arising from the 4th setigerous segment. In all other characters it agrees well with *Axiothea* Mgn., in which no such collar has been described. I have since examined authentic specimens of *Axiothea catentata*, the type of the genus *Axiothea*, sent from the Museum of Copenhagen, and found that it has a narrow collar or fold, both on the 4th and on the 3d setigerous seg-

ments, but much less developed than in *C. torquata*, when the latter has been equally contracted by alcohol. The collar is doubtless much narrower in life than in the latter, but it is of the same nature.

As *Axiothea* was in prior use in Coleoptera (Pasc., 1864) it must be abandoned for this genus, and *Clymenella* now seems to be its equivalent, both types being essentially alike in all generic characters.

This genus has the following characters: Number of segments variable. A limbate cephalic plate; a funnel-shaped anal plate bordered with papillæ; a thoracic collar on the 4th setigerous segment, and sometimes on the 3d and 5th; rows of ventral, rostrate, uncinate setæ, having a series of apical hooks and a beard, on all the anterior setigerous segments; both pennate and smooth bilimbate capillary setæ in the upper fascicles (pennate ones overlooked or perhaps accidentally absent in some described species); usually 2 or 3 preanal segments without setæ.

Besides the type, at least two other East American species are known:

C. elongata (Webst.) 1879, as *Praxilla*, from New Jersey and Connecticut. It has thirty-seven to thirty-nine segments (thirty-six setigerous in the larger ones). Mr. Moore, 1893, has also described, as a new species, *Clymenella elongata* from New Jersey, which is probably identical, though the coincidence in name was accidental.

C. mucosa (Andrews) as *Axiothea*, Proc. U. S. Nat. Mus., 1891, has twelve uncini on the 1st setigerous segment, and thirty farther back. The anal papillæ are of various lengths.

These three species all have small pennate setæ mixed with the bilimbate ones, but in *C. torquata* the pennate setæ are very small, slender and fragile, so that they are easily broken off and overlooked.

Axiothella, sub-gen., nom. nov. Type, *A. catenata* (Mgn.).

Axiothea Malmgren, 1865; St. Joseph and others (*non* Pasc., 1864).

The name *Axiothea*, as above shown, is untenable, but I propose to establish a subgenus, *Axiothella* for the typical species of *Axiothea*, making the smaller or rudimentary condition of the collar* the

*St. Joseph, op. cit., p. 131, objects to the use of the existence of a thoracic collar as a generic character, because it has been found to exist in species of other genera (*Rhodine*, etc.). But the same objection would apply to the limbate head, and to the infundibuliform anal plate, which exist in several genera. In fact it is probable that in those cases where it exists it will be found to be associated with other truly generic characters. (See p. 654.)

principal character of the group. As in typical *Clymenella*, there are pennate setæ in the better known species, and perhaps in all, for they may have been accidentally lost in some cases, or else overlooked, owing to their delicacy and fragility.

Such setæ are known to be present in the following European species: *Clymenella* (*Axiothella*) *constricta* (Clap.); *C.* (*A.*) *cirrifera* (Lang.); and *C.* (*A.*) *lyrocephala* (Schm.) from Cape of Good Hope.

The two northern species, *C.* (*A.*) *prætermissa* (Mg'n.) and *C.* (*A.*) *polaris* (Theel) are not known to have pennate setæ, but these may have been accidentally lost or overlooked.

Clymenella (Axiothella) Somersi, sp. nov.

A slender species, with eighteen setigerous segments, perhaps more in the adults. The post-abdominal segments are unusually long.

The head is rather long, with a prominent median lobe having a produced obtuse tip, with a group of orange-brown ocelli on each side below; marginal lobes thin, rather wide, erect, nearly entire, those of the two sides confluent dorsally, with only a shallow median notch.

Head and buccal segment shorter than the following two segments; 3d to 5th setigerous segments are shorter; 6th is about equal to the 2d; 7th to 9th are elongated; 10th to 15th are very long with the tori at the posterior end. The length of these in a small specimen is 30 to 38^{mm}; diameter 3 to 4^{mm}; the 16th to 18th decrease rapidly in length. Two short preanal segments lack setæ. There is a narrow collar on the 4th setigerous segment and also on the 5th.

Uncini begin on the 1st setigerous segment, on which three or four stand in a row, in specimens about 50^{mm} long; four or five in each row on the 2d; six to eight on the 4th; longer rows farther back.

The caudal segment is cup-shaped with incurved sides and enlarged or annulated base; its margin bears about twenty-four slender cirri, alternately longer and shorter, with a distinctly longer one on the median ventral edge.

The capillary setæ of the first three setigerous segments are small, slender, acute, and nearly all are distinctly pennate to the tips, with rather long denticles; on the 4th segment they are partly, and on the 5th mostly, replaced by larger and longer, narrowly limbate, smooth setæ that taper rapidly to acute tips.

The uncini of the anterior region have a large, sharp, rostrate hook, directed somewhat upward, and three (sometimes four) small appressed apical hooks.

Color, in life, is light red in the smaller specimens, and with no definite red bands. The large ones were yellowish brown.

The tubes are made of fine shell-sand, and stand upright in the sand at low-tide.

In life the smaller specimens were about 50^{mm} long and 0.5^{mm} in diameter, the larger ones about 150^{mm} long and $4–5^{mm}$ in diameter.

In consequence of the modern revisions of the Maldanidæ by St. Joseph and others, it will be necessary to establish additional generic groups. The common, large New England species described by me (1873) as *Maldane elongata* cannot be placed in any of the recognized genera, and I therefore propose to establish a new genus for it.

Maldanopsis, gen. nov. Type *M. elongata* V., 1873.

Head with a well formed limbate cephalic plate, as in *Maldane*. Caudal segment with a wide, prominent foliaceous spatulate lobe on the dorsal side, and on the ventral side a deep, funnel-like, anal opening, surrounded by a distinct semi-circular rim, without denticulations, so that the anal opening is inside the margin of the anal plate, and not outside, as in *Maldane*. This plate is, therefore, more like that of *Petaloproctus*.

The anterior setigerous segment has no uncini; the 2d and 3d have short rows of rostrate uncini. All preanal segments bear setæ.

Lumbriclymene filifera Ver.

The *Maldane filifera* V., 1879, Proc. U. S. Nat. Mus., p. 179, does not belong to *Petaloproctus*, as St. Joseph supposed, but rather to *Lumbriclymene* Sars, 1871, but it differs from the type, so that the generic characters should be altered somewhat. Its anal region consists of a somewhat flattened cone, turned up dorsally and nearly acute, but without a limbus. The small anus is close to the tip on the dorsal side of the segment, while the oblique postero-ventral side may be flat or concave. The head has a central carina with a pit each side of it, but no definite plate or limbus. The anterior ventral tori contain one or two spiniform setæ. The two short preanal segments have small tori, but no setæ.

Praxillura Ver., 1879. Type, *P. ornata* V., op. cit., p. 179.

This cannot be united to *Lumbriclymene*, as St. Joseph has done with doubt. It differs very much in having spines on about seven anterior segments and a mixture of spines and uncini on others; in having very numerous segments (about 40); and in having the anal segments small and simple, or not specialized in any way, with the anus terminal.

This is, perhaps, the most generalized or primitive type of Maldanidæ hitherto discovered. This is shown in the simple structure of the head and caudal segment; in the large number of only slightly differentiated segments; in the increased number of anterior segments with simple spines, and in the mingling of spines and rostrate uncini in intermediate segments.

Eupolymnia, nom. nov.

Polymnia Malmgren, Ann. Polychæta, p. 108, 1867 (*non* Muls., Verr., Birds, 1866). Von Marenz., 1884. St. Joseph, Ann. Sci. Nat., Ser. 7, xvii, p. 219, 1894.

The above name is proposed as a substitute for *Polymnia*, which was preoccupied in 1866.

At the same time I propose to somewhat extend its limits, in order to include a remarkable Bermuda species for which it seems necessary to establish a subgenus, *Polymniella*.

As now understood, this genus is characterized mainly by having the ordinary Terebelloid form of body and cirri, with about 17–22 anterior segments bearing smooth capillary setæ, which begin on the 4th body segment. The uncini, which are rather simple, begin on the 5th segment. They have only two rows of apical denticles, usually with 2 and 3 in the rows; a rather long base, with a tubercle at each end, and a lateral tubercle for the ligament; on some of the anterior segments they form a single row, but farther back they are in two rows that face each other. The branchiæ are arborescent, the anterior usually largest. Usually there are three pairs, arising from segments 2, 3, 4, but in *Polymniella* the last is on the 6th segment.

The very large Bermuda species, *P. magnifica* (Webst.), see p. 599, above, is a typical member of this genus. It has over 120 segments, of which 17 bear setæ, and three pairs of large arborescent gills, the first pair largest.

Polymniella, subgen. nov.

This is proposed for the following new species which agrees with *Polymnia*, except in the arrangement of the branchiæ and anterior

setæ. There are three pairs of arborescent branchiæ, but they are situated on segments 2, 3, 6; segments 4 and 5 are without any trace of branchiæ in both specimens, though it is possible that they may have been accidentally lost from those segments, and in that case there would have been five pairs; the last pair is larger than the others. The capillary setæ begin on the 2d segment (or first branchial) and continue on 22 segments.

Eupolymnia (Polymniella) aurantiaca, sp. nov.

Cirri long and slender. The first segment is medially emarginate and recedes dorsally, but it advances in a broad lobe laterally; the next segment also has a similar lateral lobe. Ventral side with 10 short, transversely oblong glandular shields, with a few narrower ones farther back. The branchial stems are usnally very short, as contracted; the branches are fine and numerous.

The uncini are much like those of typical *Polymnia*. The base is about twice as long as broad, wide and rounded anteriorly, but slightly convex, or even concave, on the basal edge. The rostrate hook is large, strongly incurved; the two apical hooks, as seen in profile, are unequal, small and closely appressed; in a top-view there is a central, rather small denticle, and five much smaller ones, standing nearly in one cross-row farther back. The capillary setæ are long, smooth, slender, scarcely limbate, mostly with delicate, thin, flat, flexuous tips.

Color, in life, orange red; the gills blood-red. Length of the largest specimen, which is mutilated beyond the 30th segment, in formalin, 50^{mm}. Castle Harbor, in dead corals. Only two specimens.

Streblosoma M. Sars, 1871.

Grymæa Malmgren, Ofver. Kong. Vet. Akad. Forh., 1865, p. 388 (*non* Fres., Protozoa, 1858).

Streblosoma M. Sars, Vidensk.-Selsk. Forh., 1871, p. 10. Type, *S. cochleatum* Sars.

The name *Grymæa* was preoccupied, and *Streblosoma* is, apparently, the only tenable name of this genus.

It is closely related to *Thelepus*, but has three pairs of clustered cirriform branchiæ, and the capillary setæ begin on the second segment (1st branchial). All, or nearly all, the segments bear setæ.

The only New England species is *S. spiralis* Ver., 1874, as *Grymæa*.

The following Bermuda species differs so much from the type that it seems to require separation as a subgenus.

Eugrymæa, sub. gen. nov.

Differs from typical *Streblosoma* in having 4 clusters of cirriform branchiæ on segments 2, 3, 4, 5, and sometimes a few cirri on the 6th segment. The capillary setæ begin on the 1st branchiferous segment, and continue on about 35 to 45 segments, or nearly to the end of the body.

Streblosoma (Eugrymæa) polybranchia, sp. nov.

Body rather slender. The two anterior segments have a lateral lobe on each side. Tentacular cirri long. Lower lip small, semicircular. The branchiæ consist of four crowded clusters of long, slender cirri on each side of the first four setigerous segments, with a few in one case on the fifth; the first ones are largest. The fascicles of setæ begin with the branchiæ; the first ones are well developed; the last observed, which are on the 45th segment, are very small. Anteriorly there are 8–10 or more long, slender ones, narrowly limbate, with very slender tips, and about the same number of shorter ones, more broadly limbate on one side, much bent distally, and with shorter tips. The fascicles become abruptly smaller beyond the 17th segment. No pennate setæ were observed.

The uncini begin on the 4th setigerous segment. They form simple curved rows of 40 or more on the anterior segments, and shorter rows of 10–14 posteriorly. They are minute, about as long as high, with an elongated base, narrowed anteriorly and ending in a small muscle-tubercle, convex on the middle of the base, but concave on the posterior margin, which inclines forward, so that the posterior end is prominent and rounded, with a small tubercle for the ligament; rostrate hook large and only a little incurved; seen in profile there are two or three small apical denticles or hooks; in a top-view there is the central rostral hook and two small hooks at its base, side by side, and one or three very minute ones in a row farther back, the middle being slightly larger and often the only one visible.

Color, in life, pale flesh-color; cirri whitish. Length, in life, about 40^{mm}. Castle Harbor, in dead corals.

Protothelepus, gen. nov.

Allied to *Euthelepus.* The first segment forms an erect, plain, narrow collar around the bases of the cirri. A single pair of long,

slender, cirriform branchiæ; they arise, close together, on the dorsal surface of the front of the 1st distinctly setigerous segment; a few small setæ occur on the branchial segment. Capillary dorsal setæ are borne by at least 17 segments (the posterior segments are wanting). Series of ventral uncini begin on about the 3d setigerous segment; all simple. The uncini are rounded basally and have no lateral tubercle; apical denticles few. A large semicircular lip projects strongly.

Protothelepus tenuis, sp. nov.

The two branchiæ are very long and slender, about 6 times as long as the diameter of the body, about equal to the cirri in diameter, and crenulated on the anterior side. Edge of buccal collar nearly even, or slightly crenulated; it has a few small, irregular pigment-spots that may be the remains of ocelli. The cirri are numerous, long and slender, strongly crenulated.

The dorsal fascicles contain 8–12 setæ, which are distinctly lanceolate, bilimbate, minutely denticulate, acuminate, with slender tips; those of the first fascicles are smaller, shorter, and less flattened; those on the branchial segment are almost rudimentary. A few small capillary limbate setæ occur on the 21st segment.

The uncini form short rows of 8–10 on the 3d setigerous segment. They increase gradually in number and form a simple row of 14–17 on segments 20–21; they are short, with a rounded incurved base and obtuse angles, and have two or three small apical hooks; the large rostral one is strongly incurved, nearly as long as the basal plate; the others are much smaller, being closely appressed to the primary one. In a top-view there are 3 series of small apical denticles, with 1, 2, and 3; or 1, 2, and 5; the last are very minute.

Length of the type (with only 21 segments remaining) about 15^{mm}.

Nicolea modesta, sp. nov.

A small, slender species with two pairs of small, slender, sparingly branched, stipate branchiæ; the second one smaller. The first segment forms a low collar, slightly scalloped dorsally, and with two rounded lobes on each side; it has a row of small ocelli.

There are 17 setigerous segments, and about 34, more posterior, which carry rows of uncini. The setæ begin on the 2d branchial segment; uncini begin on the 2d setigerous segment; they form long simple rows, turned forward, on the first six segments, but on several

following ones they are in two close, parallel rows, facing one another. They are minute, with a wide base, broad anteriorly; the rostrate hook is large, acute; the two apical hooks are very small. They resemble the uncini of *N. simplex* V. and of *N. venustula*, as figured by St. John, but the base is broader anteriorly than in the latter.

The setæ are slender, 3 or 4 longer and 2 to 4 smaller and shorter; all are slender, smooth, narrowly bilimbate, acute.

Length, in formalin, 15^{mm}. Bailey Bay, low-tide.

Loimia Bermudensis, sp. nov.

A rather stout species with three pairs of large, subequal, truly arborescent branchiæ, which have a rather long stem and very numerous branchlets, taking a somewhat conical arrangement when expanded. The lower lip is large, broadly rounded, and projects freely. There is also a large lobe partly behind it on each side. The buccal segment forms a broad hood-like fold in front of the bases of the cirri. There are also two lateral lobes on each side, on the 1st and 2d segments, below the bases of the anterior branchiæ. The fascicles of setæ commence, of full size, on the 3d branchiate segment, and are present on 17 segments. The fascicles contain about 32, in two rows, decreasing gradually in length. The larger ones are scarcely limbate, and taper gradually to sharp points. They are smooth except at the tips, where they are, in most cases, finely denticulate. The smaller ones are much more distinctly pennate on one side along the distal portion. Rows of uncini begin on the 2d setigerous segment; the rows are long, with very numerous large uncini, which on certain segments stand back to back in two parallel rows, with a parabolic ventral prolongation. They are higher than long, with five large, sharp, incurved hooks, decreasing somewhat distally; the base is oblique and convex, with an angular posterior lobe for the attachment of the ligamental filament and with a slender proximal process for the muscle attachment.

Color, salmon or pale flesh-color, in life.

Diameter 5 to 6^{mm}; length of the longest, in formalin, 45^{mm}, mutilated posteriorly.

The tube consists of a thin tough lining, covered with loosely adherent coarse fragments of shells, etc. Two specimens were taken.

Bailey Bay, low-tide, under stones.

Polycirrus corallicola, sp. nov.

A small, slender species, swollen anteriorly, attenuated posteriorly, consisting of about 45 segments in the type (perhaps immature). Cirri very numerous, slender, often clavate.

Fascicles of capillary setæ are present on 23 segments; rows of uncini begin on the 7th setigerous segment and continue to the end of the body; setæ and uncini are both present on 17 segments; 16 posterior ones have uncini only, the last rows with very few (2 or 3) minute ones, but they have filiform posterior ligaments.

The setæ are of two kinds: 4–6 smooth, slender, narrowly limbate, acute ones, often bent distally; and 5–8 more slender, bipennate ones, with rather long, hair-like denticles and very acute tips. Farther back each kind becomes shorter, stouter and fewer.

The uncini are minute, in single rows, the longest rows with about 25; they are usually longer than high, with a long, narrow base, tapering to a narrow, subacute anterior end, which terminates in a small muscle-tubercle; the posterior end of the basal plate is prominent, with a distinct ligament-tubercle; the rostral hook is large, long, incurved, nearly as long as the base; there are two small appressed apical hooks, the second one very small. In a top-view there seems to be a row of three very minute, distal, apical denticles.

The color, in life, is red. Bailey Bay, 3–4 feet, in corals.

Length of the type, 10^{mm}; diameter, 1^{mm} in formalin.

Polycirrus pennulifera, sp. nov.

A small, slender species, composed of about 65 segments, elongated posteriorly and swollen anteriorly, with numerous slender, highly contractile cirri. The setæ are present on 20 segments. Uncini begin on the 21st in very small rows and continue on about 40, or close to the end. They are very minute, and none of the rows are very long (15 or 16); they are longer than high, with a long wedge-shaped base, acute anteriorly, with a small terminal muscle-tubercle; the posterior angle is rounded and prominent; the posterior upright edge is concave in the middle; the rostral hook long, very acute, scarcely incurved, considerably shorter than the base and nearly parallel with it; there are two small, apical, closely appressed hooks, the second very small.

The setæ are slender, with the blade flattened and rather strongly bilimbate, so that they have a linear-lanceolate form, acuminate at tip; the limbus is obliquely striated, and the edge is minutely pen-

nate, so that they somewhat resemble narrow feathers, hence the name. Their form is unusual in the genus, but is similar to that of *P. denticulatus* St. Joseph.

Color, in life, bright red. Length, about 35mm. In dead corals.

Polycirris luminosus, sp. nov.

A third species of *Polycirrus* has long, slender, simple setæ on at least 31 anterior segments, accompanied by long rows of minute uncini after the 7th segment.

The setæ are numerous in the 17 anterior fasicles, of two sizes, the larger about $\frac{1}{3}$ as long as the breadth of the body, very slender, not limbate, flexuous, tapering to a long sharp point; the small ones are similar to the larger ones, and about as numerous. On segments 25–31 they are few and small. Uncini begin on the 8th setigerous segment and continue to very near the posterior end, being present on over 40 segments; they form long simple series anteriorly, but back of the 30th segment they are on pinnulæ, in smaller rows of 10–15, but with very distinct posterior capillary ligaments. The anterior ones are very minute, longer than high, with a shoe-shaped base, a little turned up and subacute anteriorly, and with a prominent heel and concave sole; the upright part is concave above the heel; the large rostral hook is about half the length of the base, little incurved; apical denticles 2 or 3, the more distal ones very minute. On the posterior segments the uncini become higher, with a shorter base, and with two minute apical hooks in a side-view.

Color in life, bright red. It is brilliantly phosphorescent with a bluish light. Bailey Bay, 30–40 feet, among dead corals.

The descriptions of the two following very interesting species have been prepared by Miss Katharine J. Bush:—

Sthenelais setosa Bush, sp. nov.

Although only the anterior portion of an example belonging to the genus *Sthenelais* was found, it seems so to differ from all the species previously described from the West Indian and southern Atlantic faunæ as to deserve description.

The 27 segments occupy a length of about 10mm, with a width, including the setæ, of 3mm.

The cephalic lobe is about twice as broad as long, but little rounded posteriorly and well rounded anteriorly, with a large, trilobed basal

portion of the median tentacle arising from the middle of its dorsal surface and reaching well forward. The central portion, to which the long, smooth, tapered, median tentacle was attached, is about three times as long as broad, vase-shaped, and attached to the cephalic lobe by a slender, short stem, with a narrower, shorter, leaflike lateral lobe (ctenidium) on each side. There are four eyes; the very large posterior pair are situated just at the base of this lobe and the very small anterior pair lie just underneath the posterior edge of the lateral lobes. There is a pair of conspicuous setigerous lobes, reaching forward from the anterior surface of the cephalic lobe, each of which bears a cirrus of moderate length, arising from its median dorsal surface, above which is a cluster of numerous very fine, hairlike setæ, corresponding in number and form to those of the dorsal bunch of the lobes of the parapodia. Arising from the ends of these lobes are setæ of various forms, similar to those of the ventral bunch of the feet. Arising from the sides of the head, and partly consolidated with the cephalic lobe, are a pair of long setigerous lobes similar in form to those on the following segments. The first one is without a cirrus, but at its base is a conspicuous fleshy lobe, to the upper surface of which is attached the first pair of scales, or elytra; underneath and reaching out from the side of this lobe is the short dorsal cirrus of the second pair, which has a large swollen basal portion and a short tapered end.

Each of the following segments is furnished with a similar, but larger, dorsal cirrus, to the upper surface of the swollen basal portion of which the elytra are attached (on segments 1, 2, 4, 6, 8, 10, 12, 14, 16, 18, etc.). Only a few of the anterior elytra are present. These, which have a somewhat rounded form, are white and very thin, with the posterior edge ornamented with a few short, unequal, somewhat tapered filaments, and on the upper surface having very minute, scattered spinules. A slender ventral cirrus is present on all the setigerous lobes, those on the front of the head being much longer than the others.

From the ventral surface of the head arise the tentacle and palpi (only those on one side of the head are perfect, but they were presumably arranged in pairs). Attached underneath the base of the lateral setigerous lobe is a moderately slender, smooth, tapered, lateral cirrus, reaching to about the end of the ventral setæ.

Underneath the frontal, setigerous lobe arises a very long (3^{mm}), stout, smooth, tapered palpus; attached to the side of this and somewhat underneath, is a moderately slender, smooth tapered tentacular cirrus, about as long as, and similar to, the lateral cirrus.

From near the center of the head and below these other organs, arises a peculiar shaped one, attached to the head by a long, slender stem, having a rounded swollen central portion, with a moderately long, rather blunt, articulated, curved terminal portion.

Setæ of the dorsal bunch of one form, very numerous, like fine tapered hairs of graduated lengths, very delicately microscopically spinulose. There are four distinct forms in the ventral bunch. There are 8 or 10 in the lowest series, of graduated lengths, having smooth, slender, tapered, 2–4-jointed terminal portions, with delicate bifid tips, affixed in broader, shorter basal portions; above, a series of 8–10 with short, broad, graduated terminal portions having conspicuously curved, bifid ends, affixed in much broader, very long basal portions; above these, 3 or 4 long, slender ones, with 3–4-jointed, smooth, terminal portions having delicately tapered ends, affixed in broader, conspicuously spinulose basal portions; above these, 3 or 4 shorter stiff ones, conspicuously spinulose and rather broad, with regular tapered, striated or delicately banded ends.

Other species from this region belonging to the Sigalionidæ (Sigalionina Kinberg, 1855–58) are *Sthenelais articulata* Kinberg, 1855–58; *Sigalion Edwardsi* Kinberg, 1855–58 (= *Thalanessa* Baird, 1865); ? *Sigalion pergamentaceum* Grubé, 1855; and *Sigalion Pourtalesii* Ehlers, 1887.

The *S. articulata* differs in having long, articulated palpi, a smaller tentacular lobe, and smaller eyes.

Chrysopetalum elegans Bush, sp. nov.

Two specimens of a very beautiful species belonging to the above genus were collected in 1–3 feet. The larger one has about 65 segments and measures 15^{mm} in length and 2^{mm} in greatest breadth, including the setæ, and about 1^{mm} in thickness.

The paleæ are of a beautiful light golden color and are arranged in two series of from 15–20 on each segment, spreading out like a bunch of palm leaves, and from about the ninth segment meeting over the center of the back, forming a conspicuous ridge along the dorsum of the body. They have the form of long, narrow leaves, with coarsely serrulate margins, curved upward, and long spinulose tips; the center having coarse, equally separated, longitudinal ribs, 5 or 6 in number, running the entire length; the entire surface is also cross-striated and covered with microscopic granules.

The dorsal and ventral rami are well-separated, making the body somewhat angular in outline. Each is supported by a single aciculum. The dorsal one the shorter, with a prominent, swollen, brown-

ish terminal portion, to which the rather stout, abruptly tapered cirrus is attached ; this reaches a little further than the paleæ and often shows a dark color-patch near its inner end; the surface of both is distinctly microscopically granular. At the base and in front of this swollen portion, the setæ, about 10 in number, arise; they are of one kind, being similar in form to the paleæ, but narrower and more regularly tapered, and often have a conspicuous triangular process attached near their bases for their entire width.

The ventral ramus is less rounded and broader, and bears numerous, fine, jointed setæ of one form, their terminal portions being rather long and narrow, but little tapered, finely serrulate along their inner edge, with curved bifid tips, the shafts conspicuously pointed and longitudinally ribbed. The ventral cirrus is of moderate length, abruptly tapered.

On the back of the head there are three pairs of subequal black spots, apparently ocelli; those of the first and third are well-separated; those of the second pair, which is midway between these, are close together, nearly touching each other. On the perfect example the paleæ do not meet in the center so that they are readily seen on the first eight segments.

Only two other related species have been described from these waters :—*Palmyra elongata* Grubé, 1856, and *Bhawania Goodei* Webster, 1884 ; the latter was also found by Professor Verrill at Bermuda.

GEPHYRÆA.

Four or five species of Gephyræa were obtained with large numbers of interesting annelids, by breaking up masses of dead, or partly dead, massive corals from the reefs. Several large and beautiful species of *Leodice*, *Marphysa*, *Nicidion*, and *Paramarphysa* were secured in this manner.

The commonest gephyræan in corals is *Physcosoma varians* (= *Phascolosoma varians* Kef.). It is 1.5 to 2 inches long, clavate posteriorly, and thickly covered dorsally with black or brownish black specks and transverse patches, especially on the anterior part, where the blackish color is usually crossed by pale bands of varying breadth ; ground-color pale salmon. Posterior region closely covered with large, conical, brown grains or papillæ, becoming longer near the tip. The grains are lower with rounded tops on the mid-dorsal region; smaller and fewer beneath ; near the base of the proboscis they become conical and crowded. The distal part of the proboscis is surrounded by about 20–30 close rows of minute, black, curved,

acute, hooks, arranged closely side by side in each row; these are followed by close circular rows of minute rounded granules, which increase in size proximally.

The integument is firm, but somewhat translucent, and contains about 30 principal muscular bands, with irregular smaller ones between them.

This species appears to be the same as *Sipunculus granulatus* Pourt., 1851, from Florida, but it is probably distinct from the European *Physcosoma granulatum* (Leuck.).

It is evidently very closely related to, and perhaps identical with, *P. Puntarenæ* (Œrst & Gr., 1858), described from St. Croix.

Phascolosoma cylindratum Kef.

The second species is about 40^{mm} long and $3–4^{mm}$ in diameter, translucent whitish, tapering posteriorly, and almost perfectly smooth, but with microscopic pale granules posteriorly and with rows of minute, obtuse hooks on the anterior part of the proboscis; tentacles small, papilliform. This was more abundant in shell-sand at low-tide and under stones. The original type was from Bermuda.

Aspidosiphon spinulosum, sp. nov.

A third species, belonging to *Aspidosiphon*, was found in dead corals. The body is about 20^{mm} long; the probosis 24^{mm}, as preserved, and slender. The posterior shield is round, convex, light brown, with many radii; the siphonal shield is round, dark brown, covered with angular chitinous grains. The body is granulated with minute chitinous points close to the posterior end; the proboscis is covered above with minute black, sharp, recurved spinules, becoming fewer and smaller beneath. The large retractor muscles are attached far back.

Golfingia elongata, sp. nov.

The fourth species is, perhaps, a *Golfingia*. Its body is slender, about 20^{mm} long, 2^{mm} in diameter; the extended probosis is $15–20^{mm}$ long and about 1^{mm} in diameter. Color, yellowish brown. The horny ring at the base of the proboscis is dark brown, wide, and gibbous dorsally, much narrower beneath, tapered anteriorly, covered with strong longitudinal and divergent ridges. The posterior shield is round, conical, with fine radial lines. The proboscis is rugulose, wrinkled, covered with minute, sharp, erect spinules, arranged without order. It is darker brown than the body, which is white posteriorly and smooth for about $\frac{1}{3}$ of its length.

EXPLANATION OF PLATE.

Plate LXX.

Figure 1.—*Lineus albocinctus*, sp. nov. Dorsal view. $\times 1\frac{1}{2}$.
Figure 1*a*.—The same. Side view of head. Enlarged.
Figure 1*b*.—The same. Dorsal view of head. Enlarged.
Figure 2.—*Lineus albonasus*, sp. nov. Dorsal view. Natural size.
Figure 3.—*Tæniosoma curtum* (Hubr.). Dorsal view. $\frac{1}{2}$.
Figure 4.—*Barentsia timida*, sp. nov. $\times 10$. From a photograph.
Figure 5.—*Pseudoceros superbus* Lang. Dorsal view. Natural size.
Figure 6.—*Pseudoceros pardalis*, sp. nov. Dorsal view. $\frac{2}{3}$.
Figure 6*a*.—The same. Posterior part. Ventral view; *a*, mouth; *b*, male genital pores; *c*, female genital pore; *d*, sucker. Enlarged.
Figure 7.—*Cistella cistellula*. Dorsal and ventral sides. $\times 10$.
Figure 8.—*Diazona picta*, sp. nov. One small lobule. About natural size.
Figure 9.—*Ammothea* (*Ammothella*) *rugulosa*, sp. nov. Much enlarged; from a photograph.
Figure 10.—*Achelia* (?) *gracilis*, sp. nov. Much enlarged; from a photograph.

ERRATA.

Page 21, line 4, for 15 read 14; line 7, for 14 read 13; line 12, for 14 read 13; line 17, for 13 read 16; line 20, for 16 read 15.
Page 48, line 38, for matter read water.
Page 58, line 24, for Linné read Müller; line 32, for Linné read Müller.
Page 59, line 15, for Linné read Müller.
Page 62, line 20, for D. read P.
Page 72, line 30, for Chemn. read Müller.
Page 78, line 23, for *Mülleri* read *striatus*.
Page 91, line 11, for P. read N; line 25, add C. bifrons, 55.
Page 91, line 27, add 76 after 67; line 27, omit 76 after 68.
Page 92, line 29, omit 73.
Page 93, line 26, for *parvus* read *nanus*.
Page 102, line 19, for are read were.
Page 103, line 11, for 1848 read 1842.
Page 108, line 10, for or read *nec*.
Page 121, line 4, for pillow read pillar.
Page 124, line 3, for callus read callous; line 36, for callus read callous.
Page 133, line 15, for 1865 read 1883.
Page 134, line 16, for 202 read 201.
Page 139, line 36, for lvi read lviii.
Page 201, line 6, for Ludiinæ read Luidiinæ.
Page 342, line 11, for Ophiectodia read Ophientodia.
Page 357, line 15, for Ophioscolicid read Ophioscolicidæ.
Page 359, line 22, for *Ophioscolecidæ* read *Ophioscolicidæ*.
Page 361, line 18, for *Ophioscolecidæ* read *Ophioscolicidæ*.
Page 381, line 10, for Ophiobraciontidæ read Ophiobrachiontidæ.
Page 493, line 6 for 1876 read 1853, as *sancta-georgiensis;* line 7, for 1888. Heilprin, Stone, read 1878. Bartram.
Pages 494, 495, 496, 501, 502, for Cook read Cooke.
Pages 495, 497, for M. C. Cook read C. M. Cooke, Jr.
Page 496, line 2, from bottom, for 1888 read 1878.
Page 506, line 25, add Prime's list is in the Bermuda Almanac for 1853.
Page 507, line 9, after *sancta-georgiensis* add=*H. appressa*.
Page 513, foot note, for M. C. Cook read C. M. Cooke, Jr.
Page 515, line 29, for *Pleurorbranchus* read *Pleurobranchus*.
Page 521, line 26, for *reticula* read *reticulata*.
Page 525, line 5, for *Montrouzier* read *Montrouzieri*.
Page 539, line 36, for *Mangonia* read *Manzonia*.
Page 544, line 2, for 15 read about 11; line 3, for 15 read about 8; line 21, for 12 read 16; line 22, for 6 read 9; line 33, for about 4 read 12.
Page 554, line 5, for 1876 read 1872; line 25, for 1887 read 1889.
Page 584, line 16, for 40 read 41; for all read nearly all.
Page 584, line 23, for *Ophidiaster* read *Linckia*.
Page 615, line 4, for P read H.
Page 616, line 18, for Typanosyllis read Trypanosyllis.

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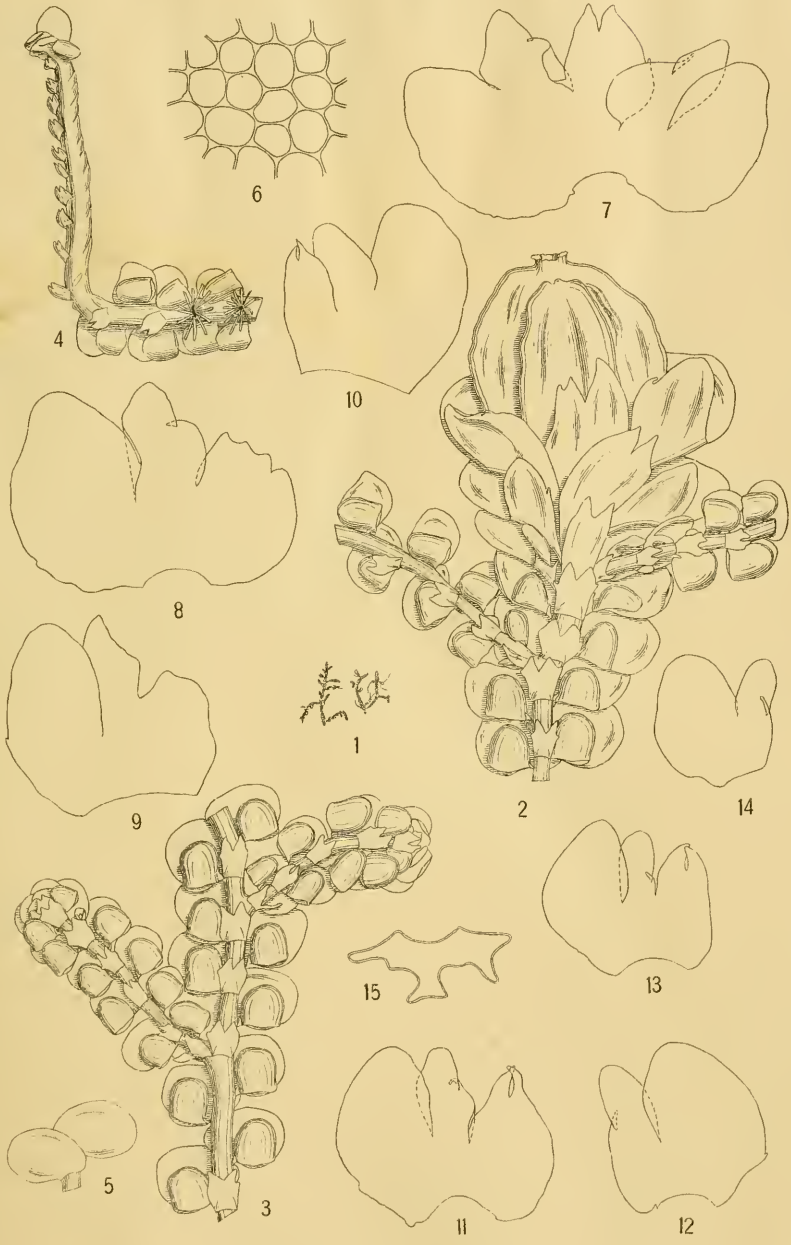
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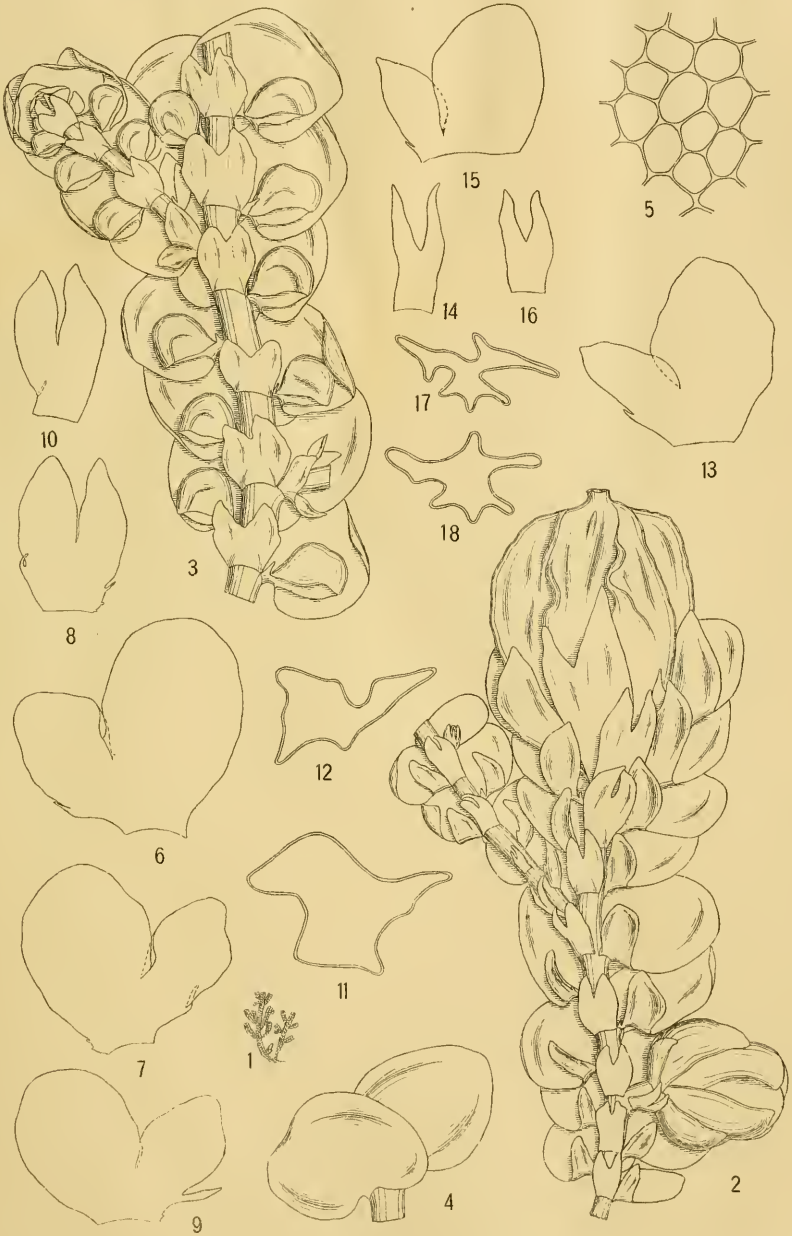
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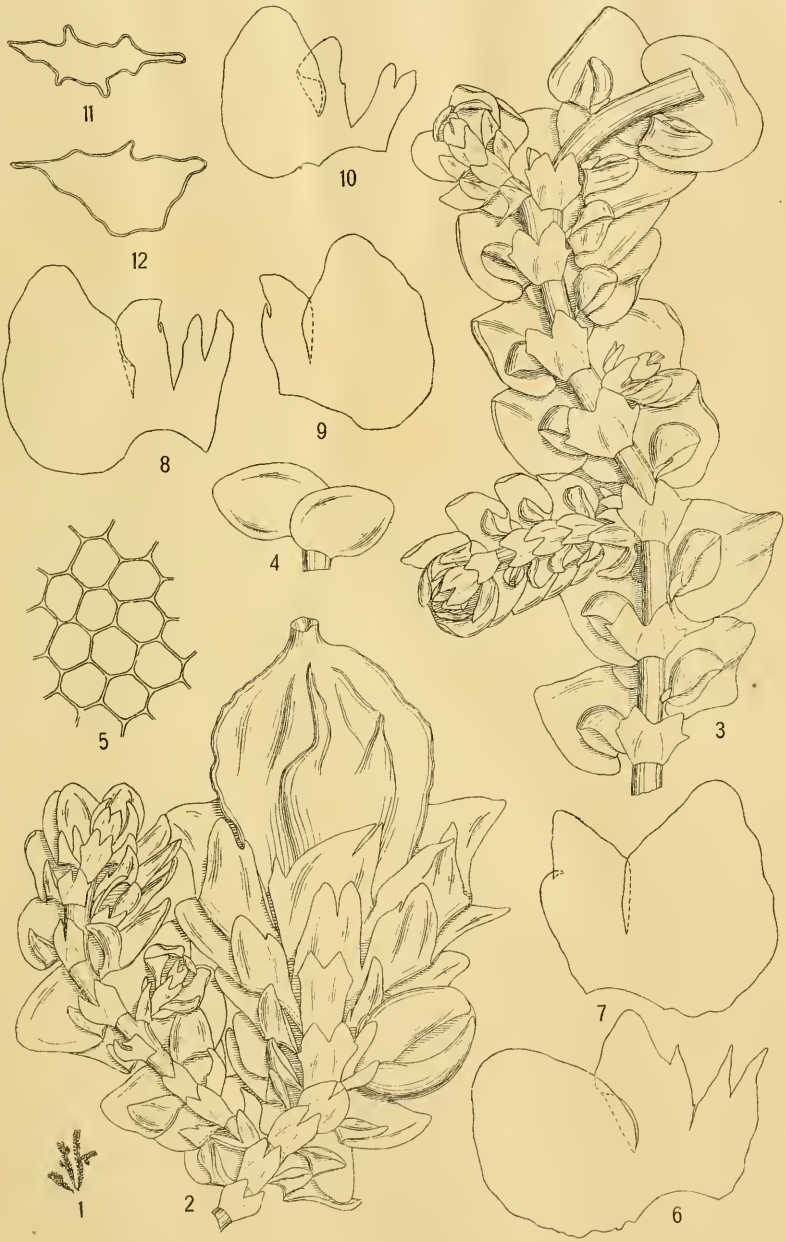
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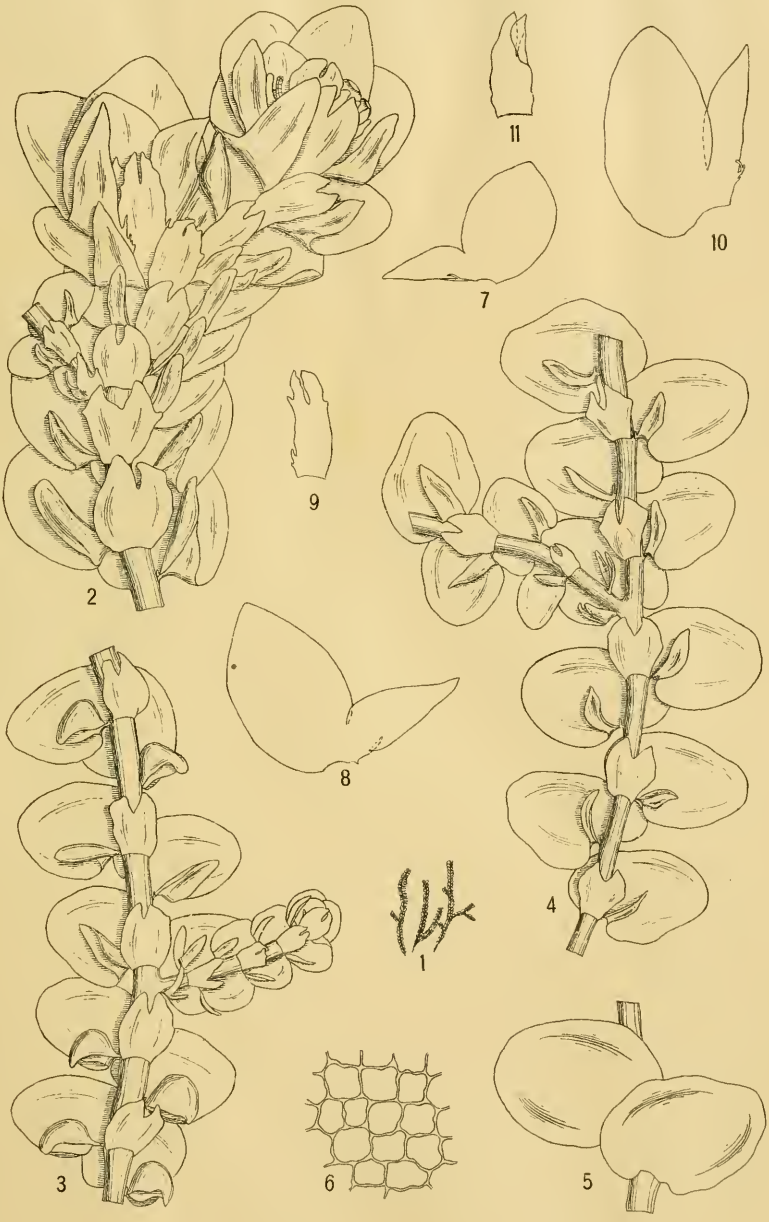
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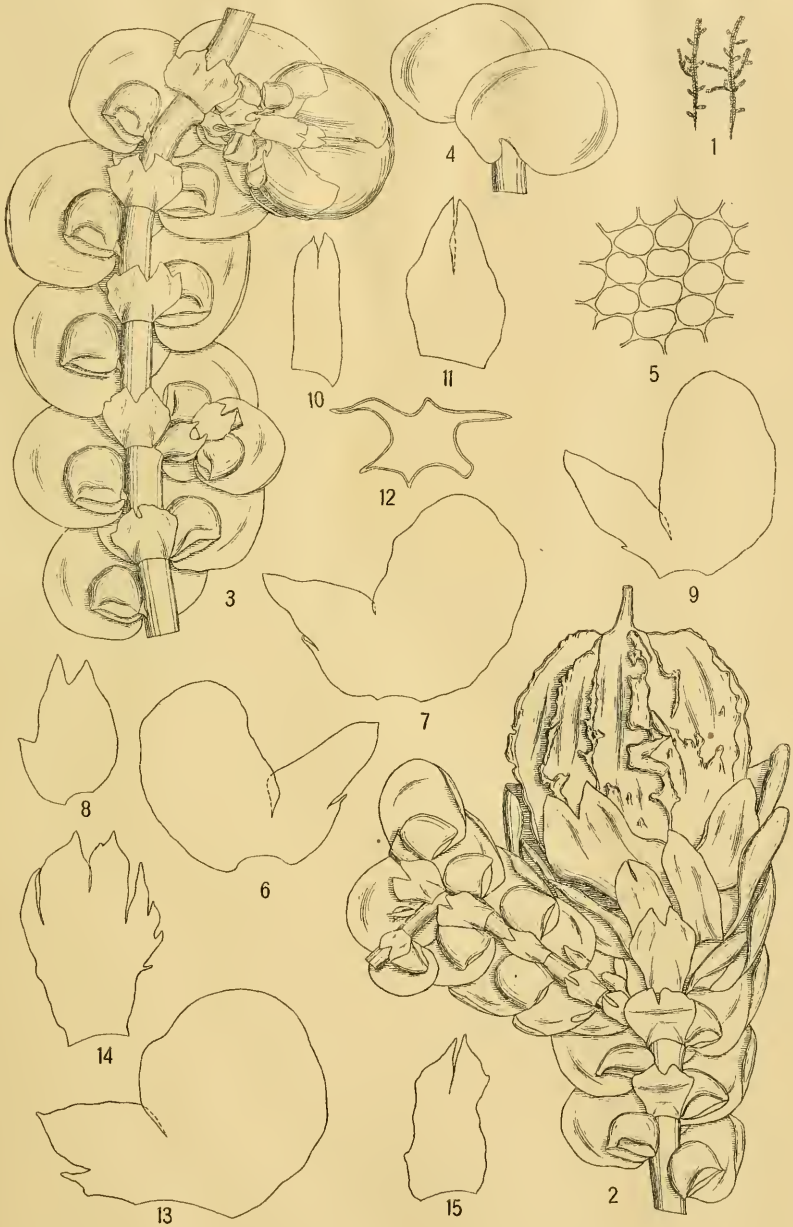
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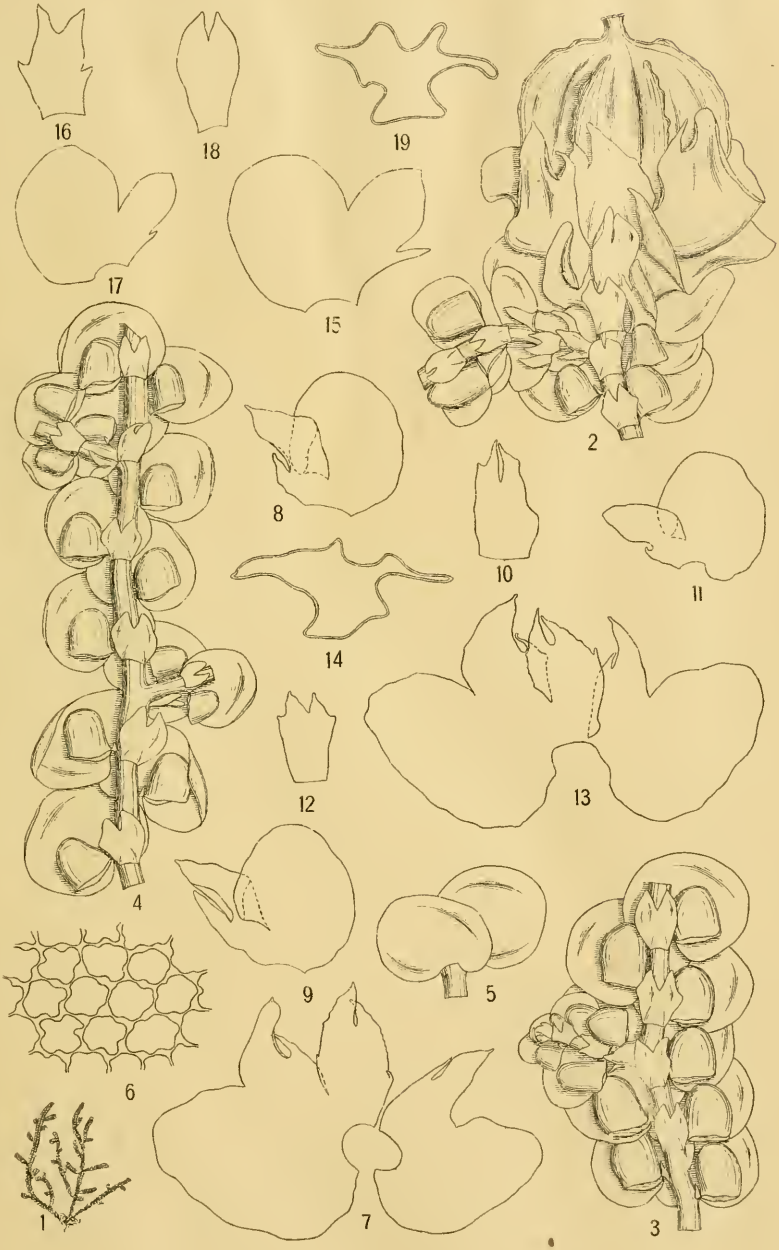
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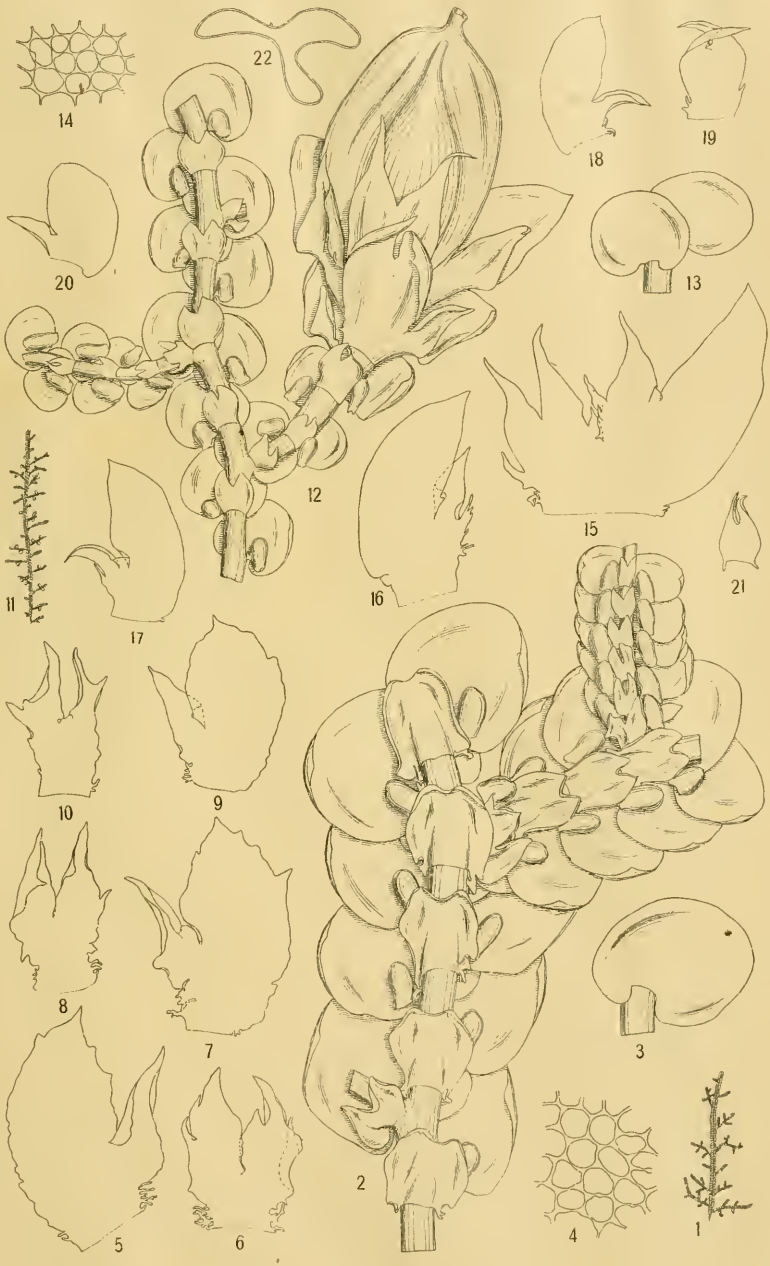
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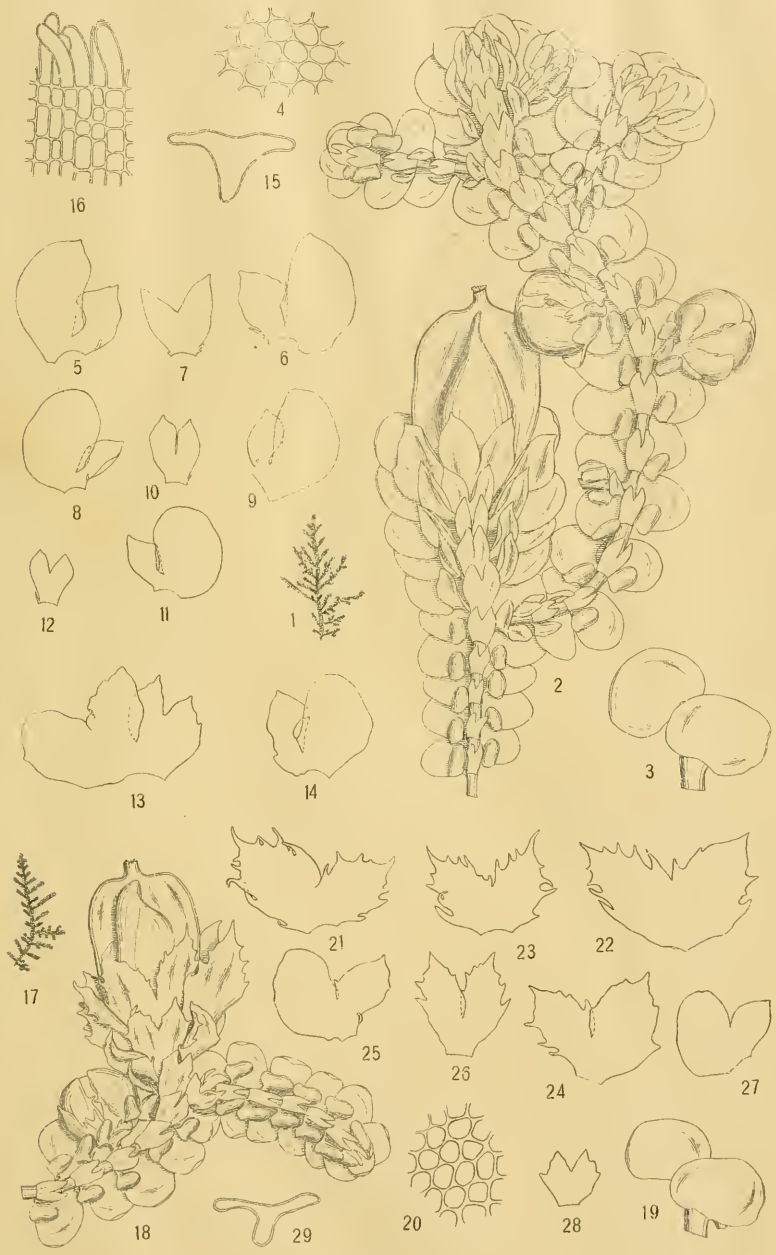
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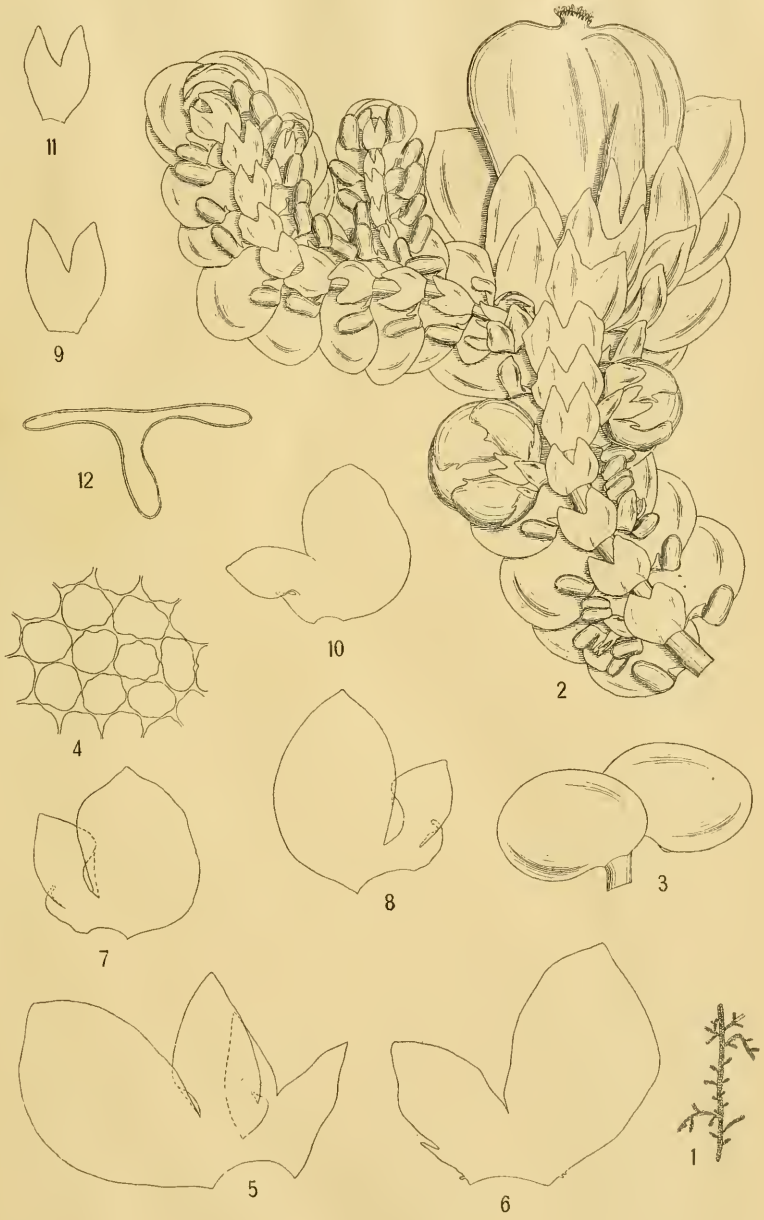
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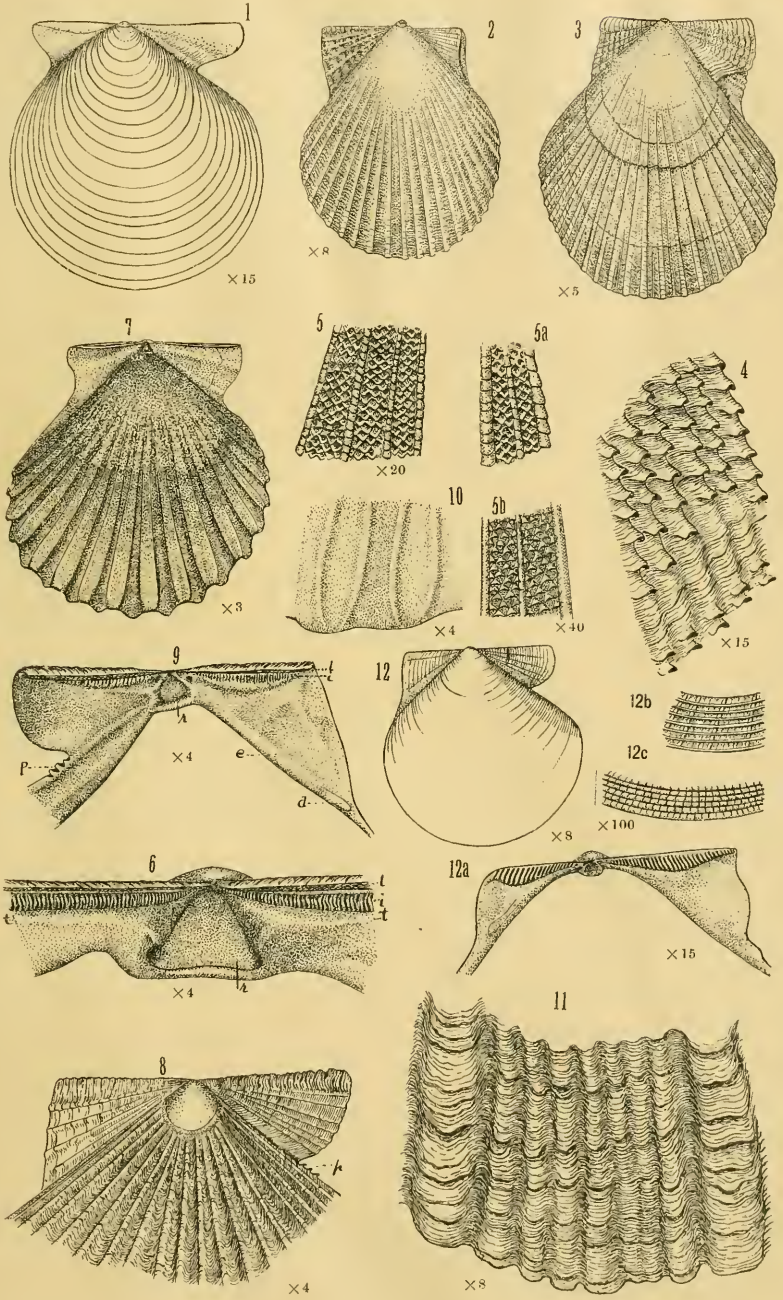
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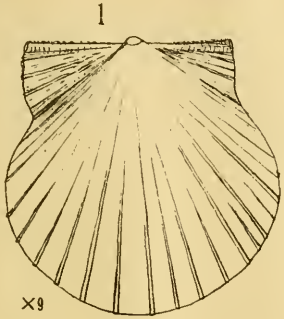
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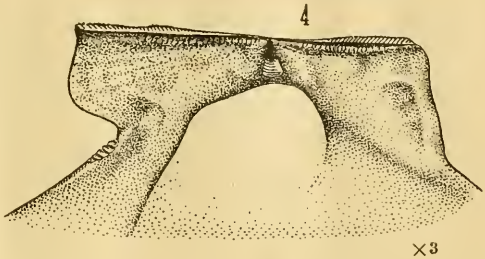
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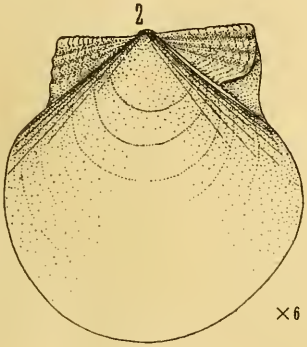
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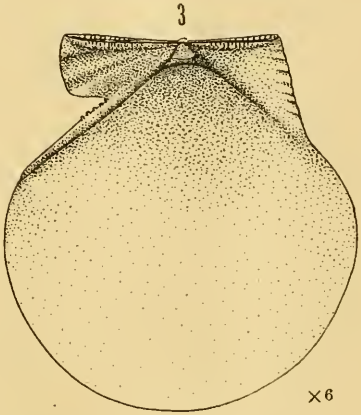
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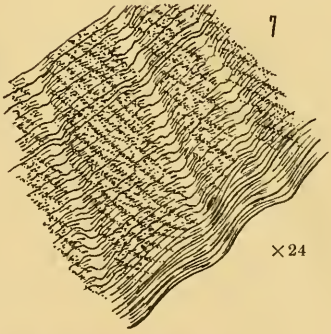
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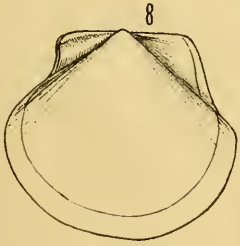
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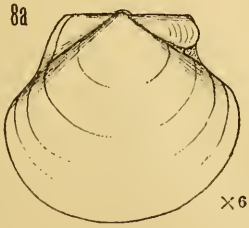
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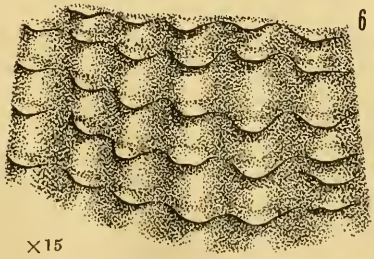
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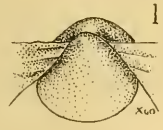
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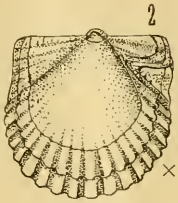
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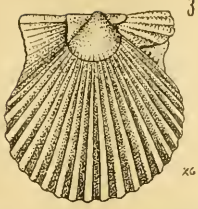
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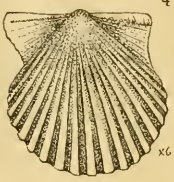
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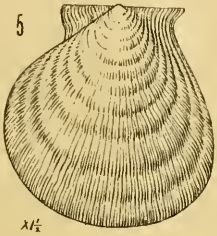
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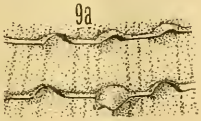
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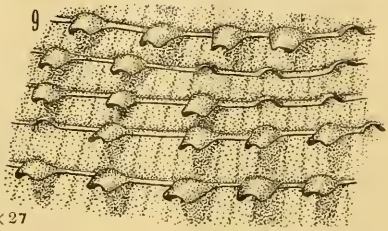
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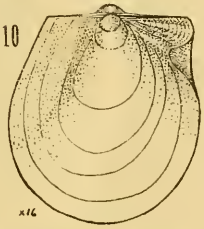
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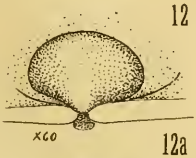
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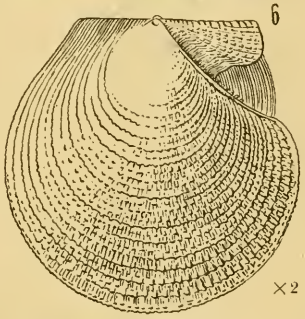
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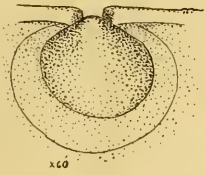
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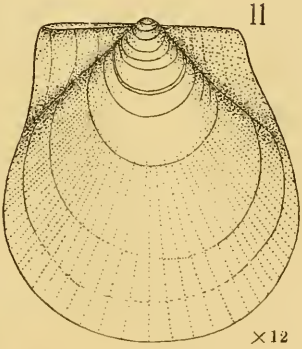
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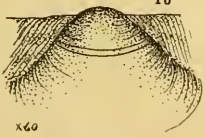
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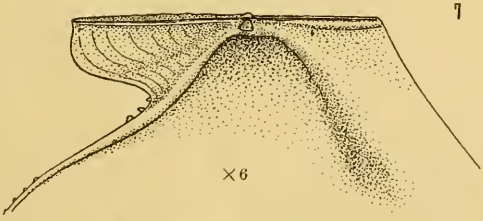
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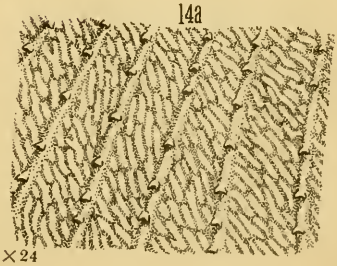
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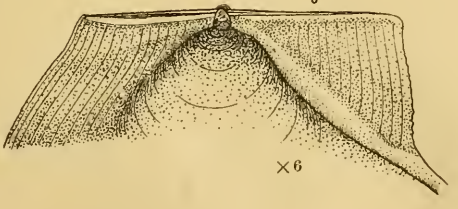
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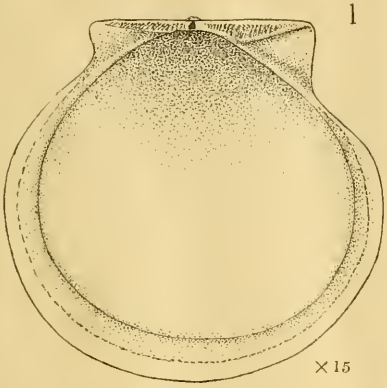
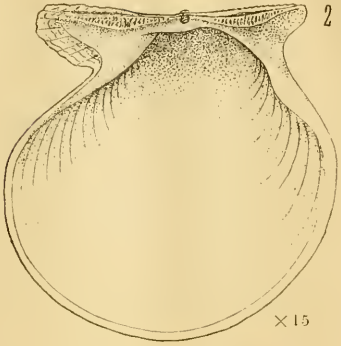
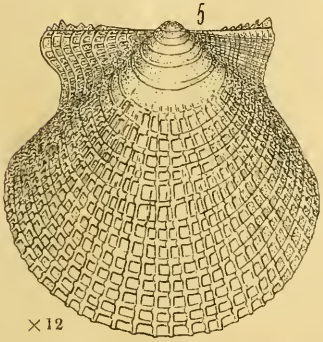
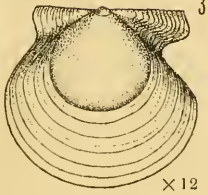
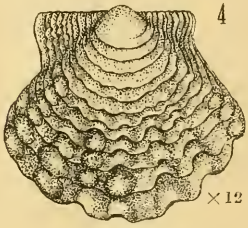
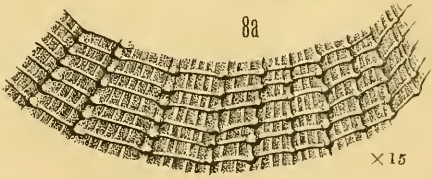


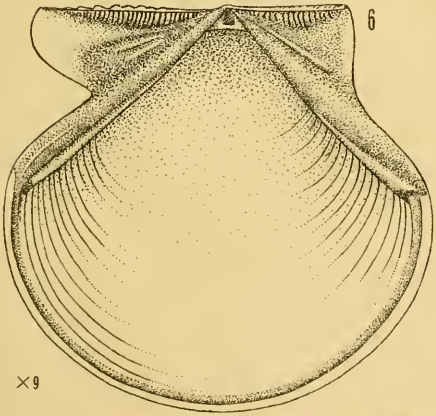


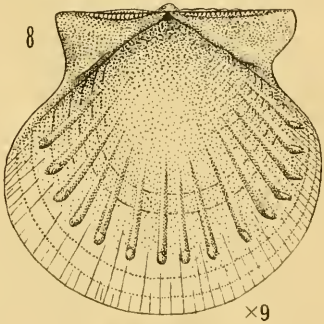


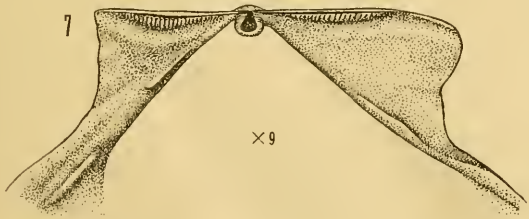


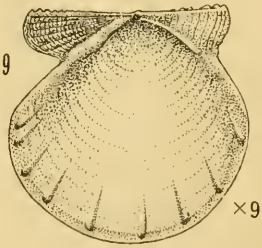




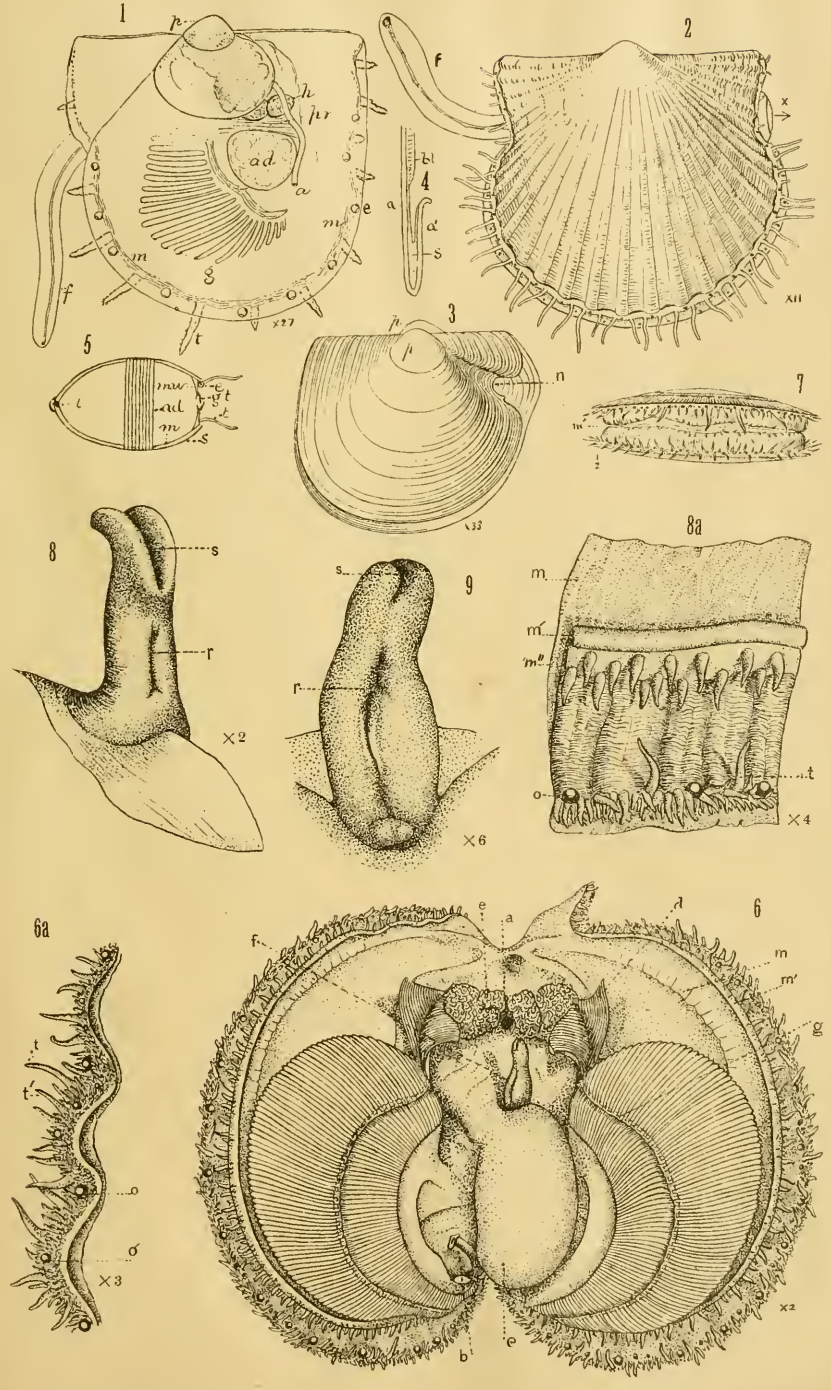






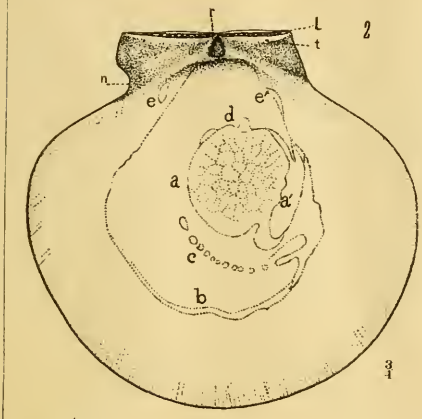


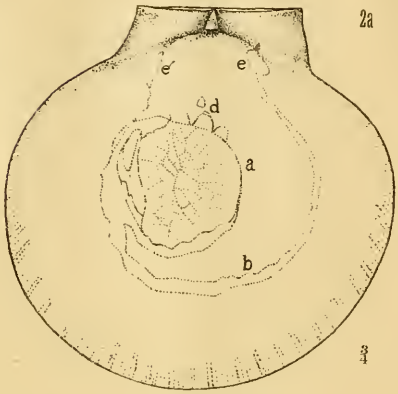
A.H.Verrill, from Nature. Heliotype Co. Boston.

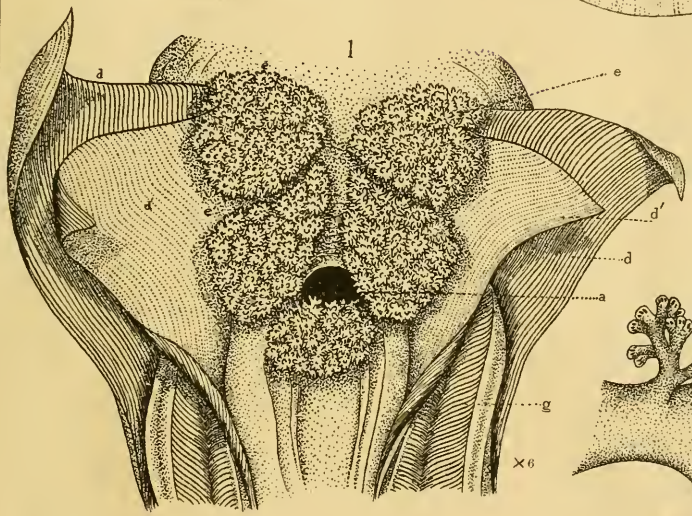


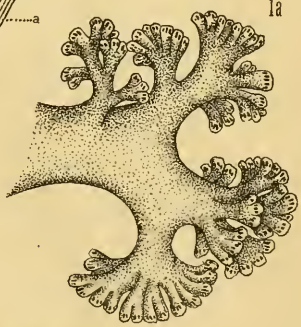
A.H.Verrill, and Dr.Jackson from Nature

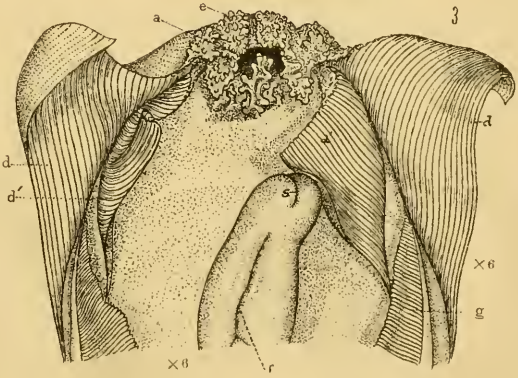
Heliotype Co. Boston



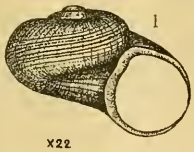








A.E.Verrill, from Nature. Heliotype Co, Boston.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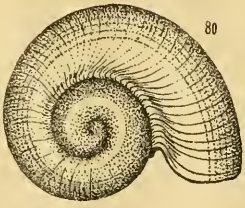
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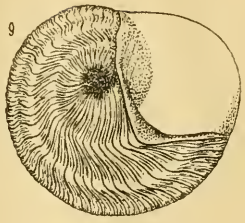
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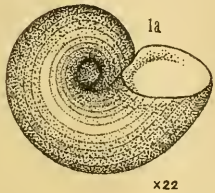
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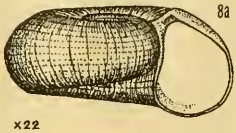
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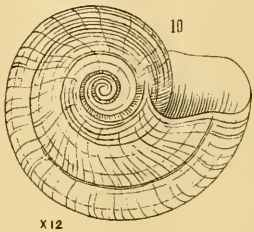
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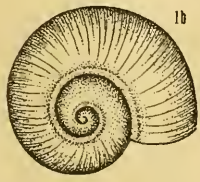
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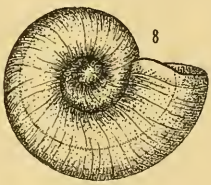
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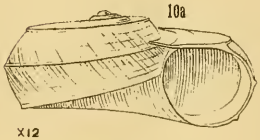
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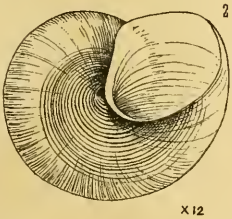
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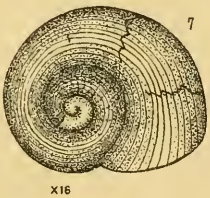
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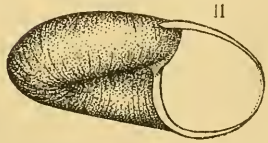
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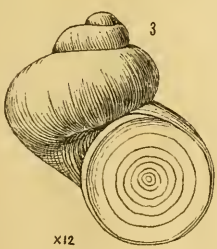
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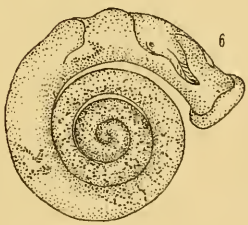
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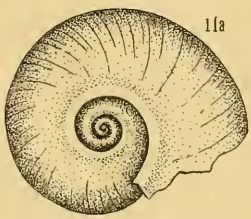
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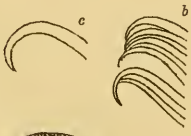
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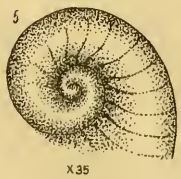
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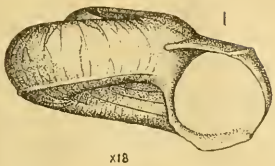
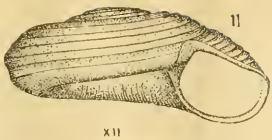
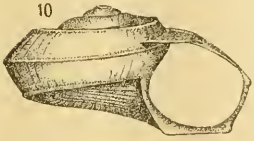
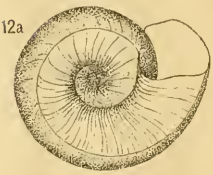
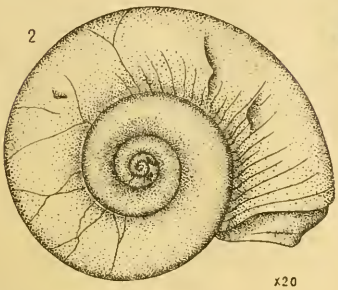
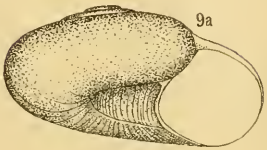


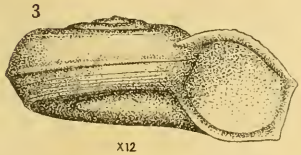


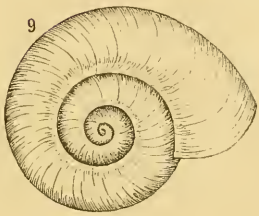


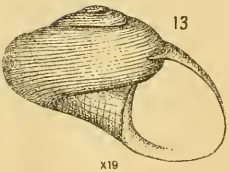


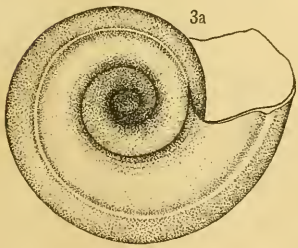


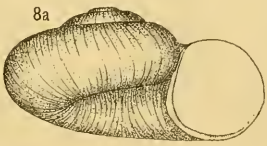


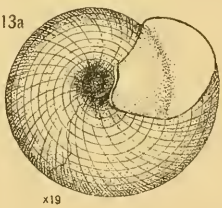


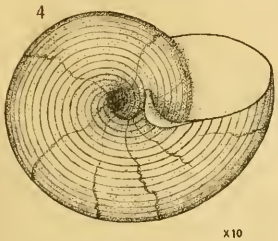


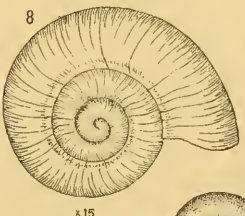


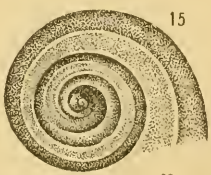


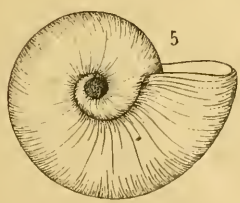


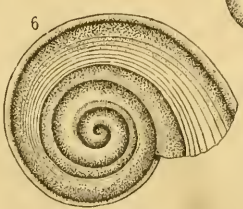




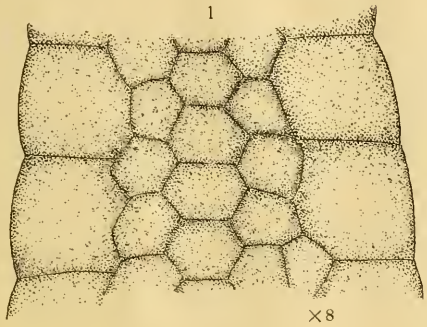








A.H.Verrill, from Nature. Heliotype Co., Boston.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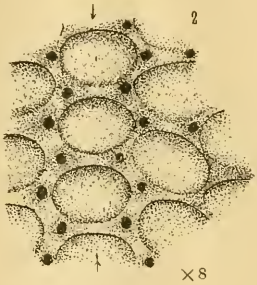
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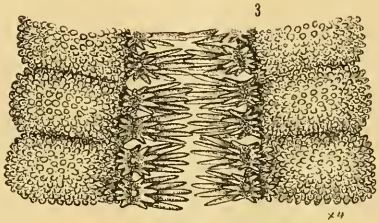
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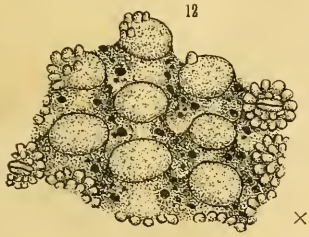
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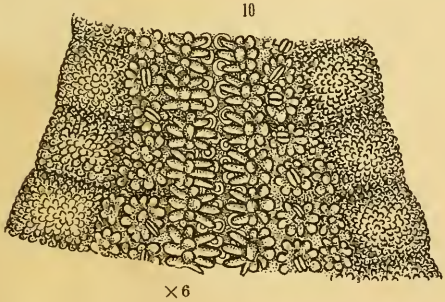
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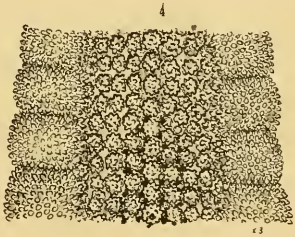
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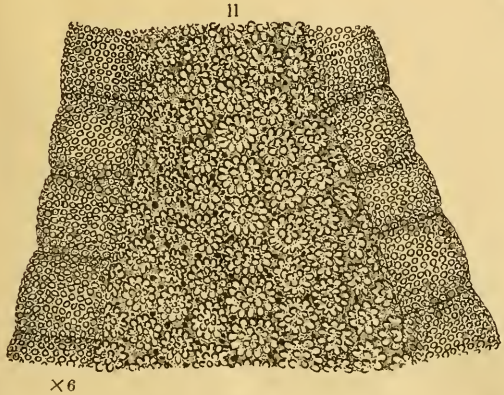
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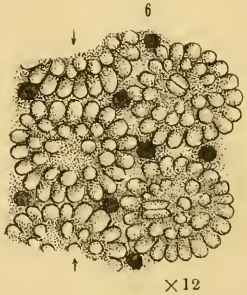
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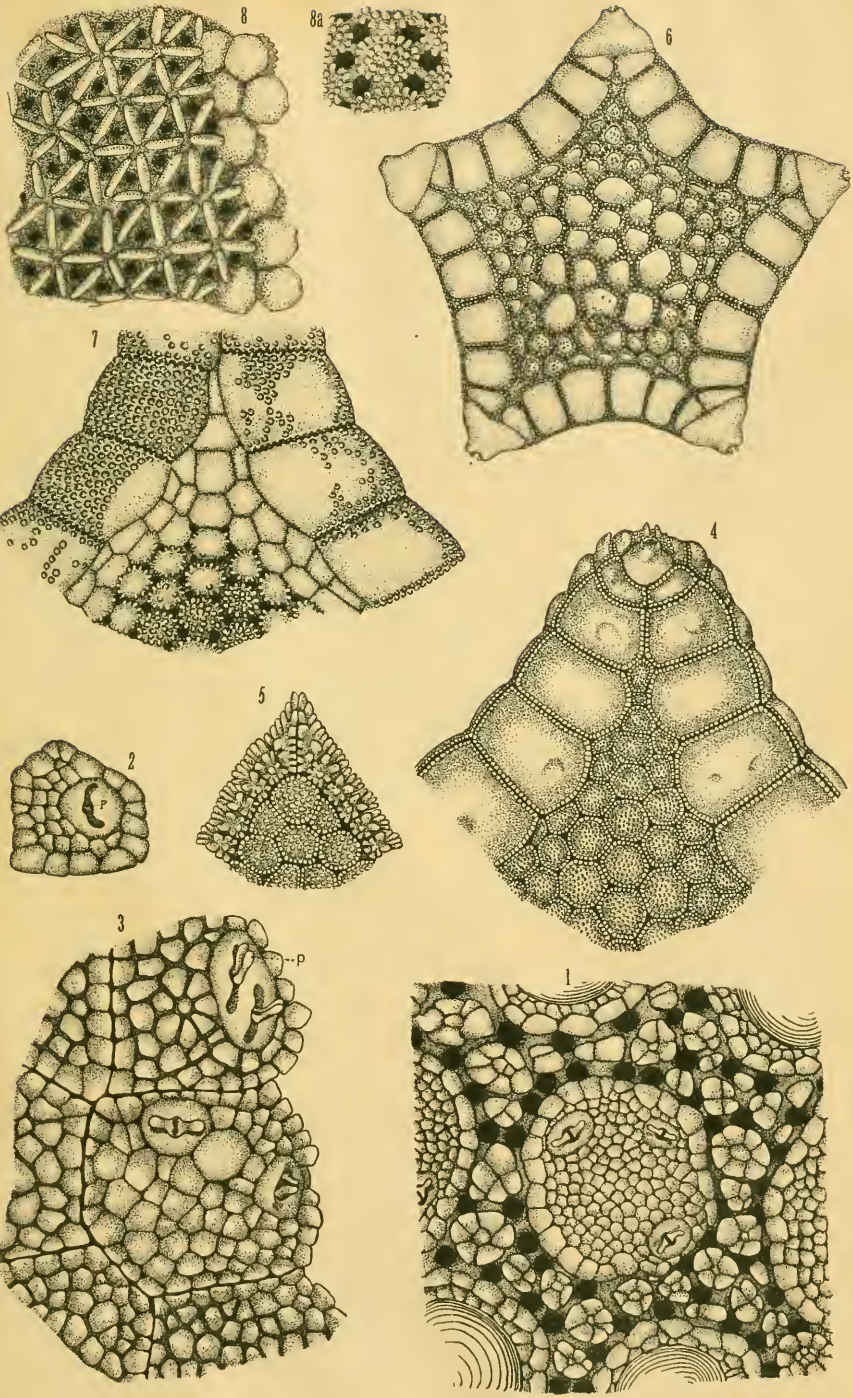

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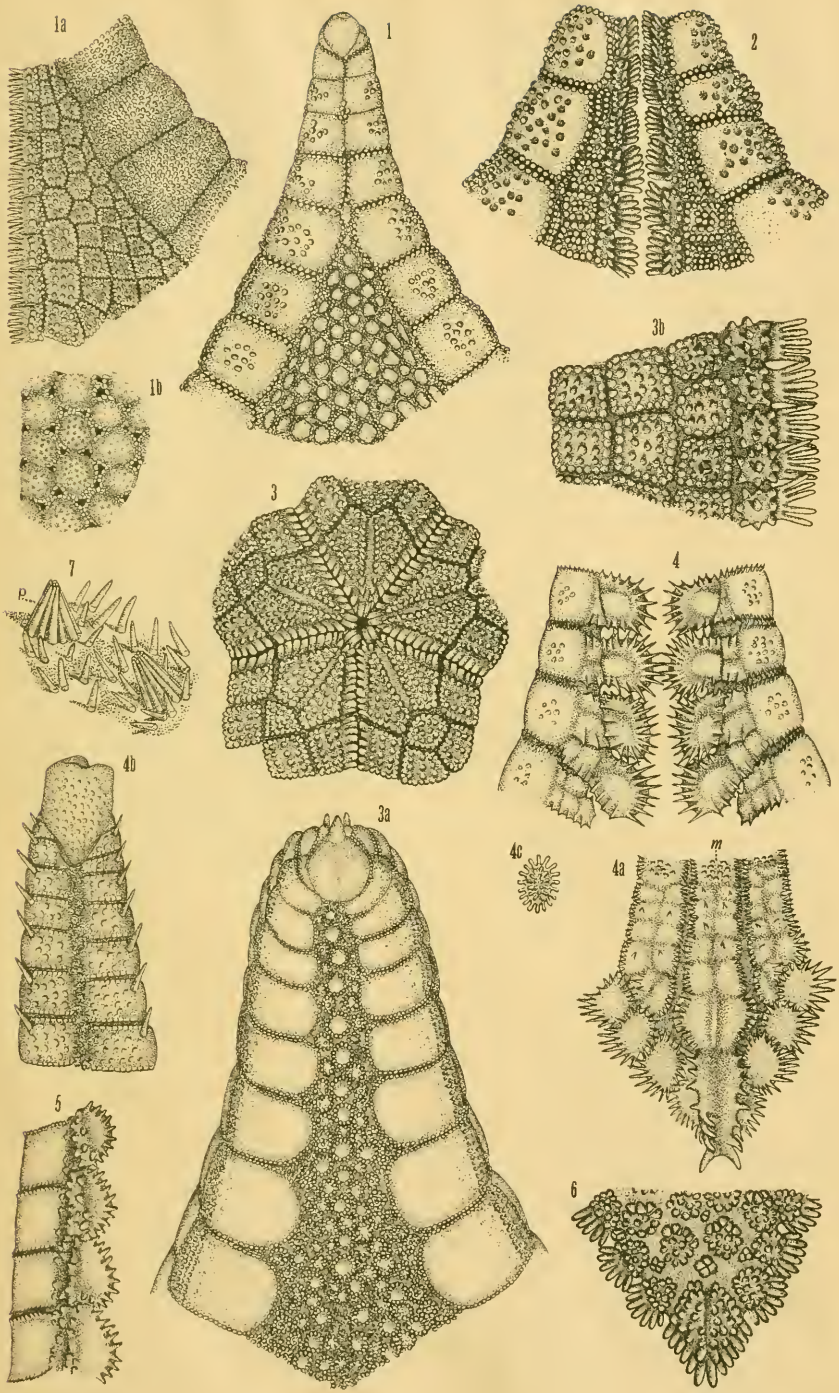

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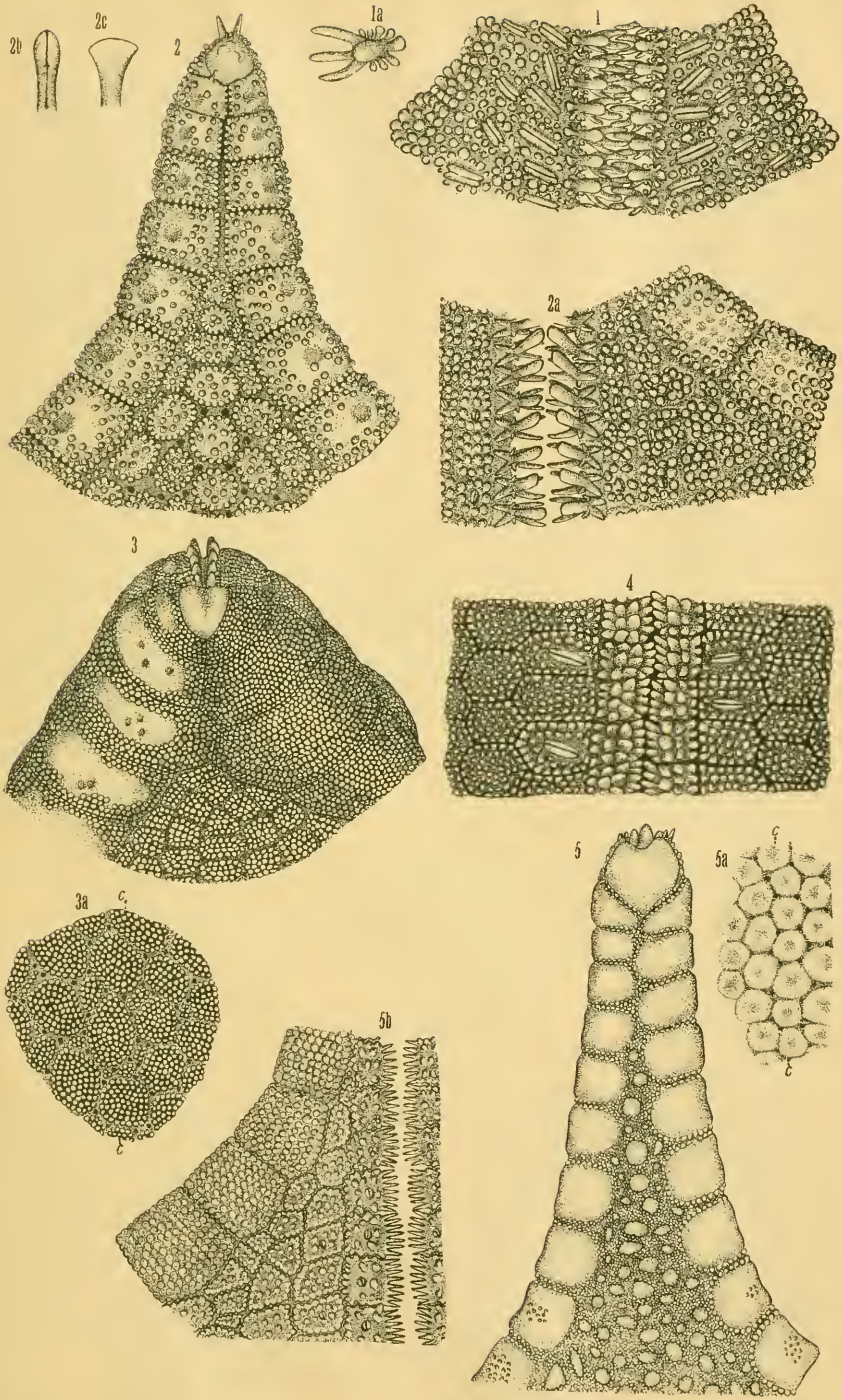

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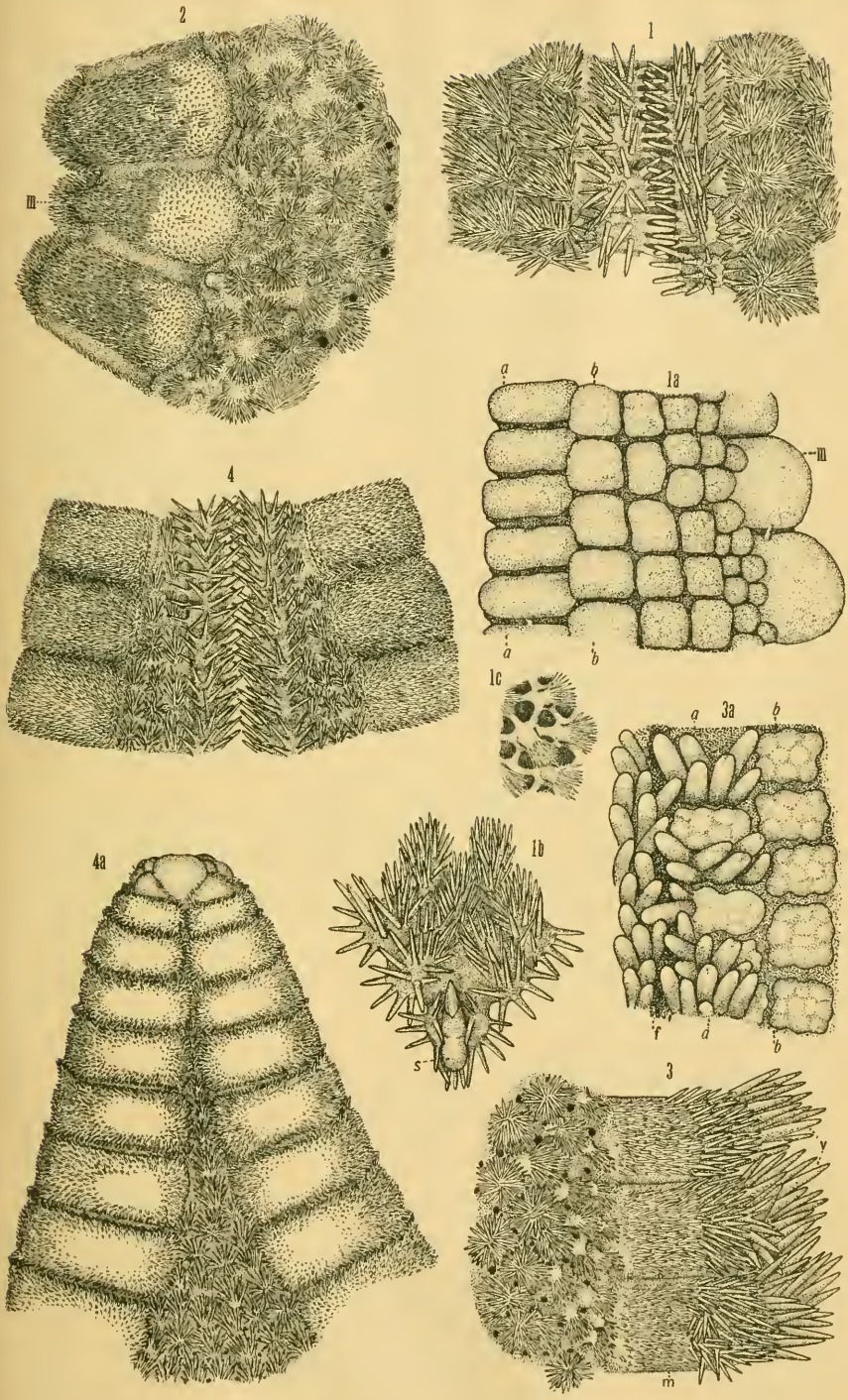

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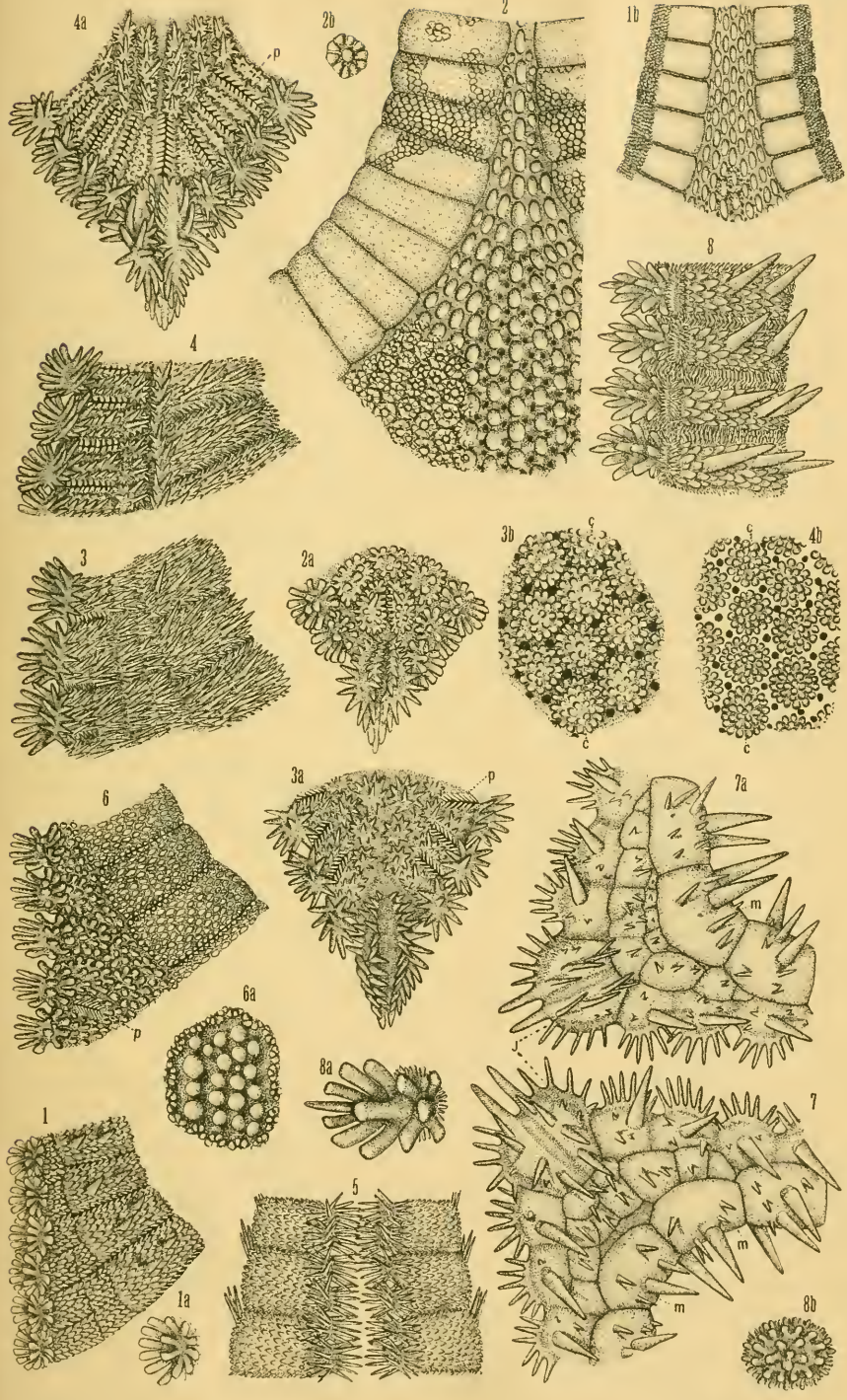

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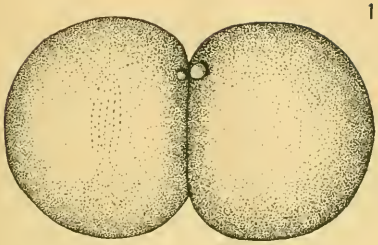

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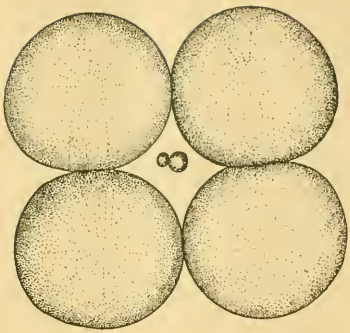

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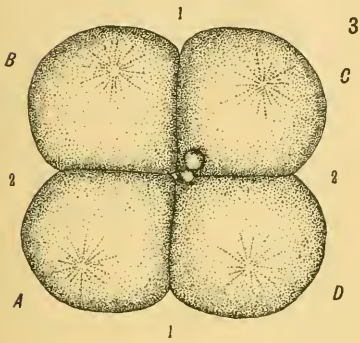

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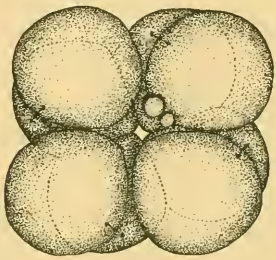

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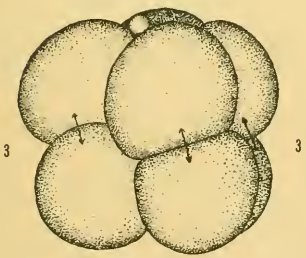

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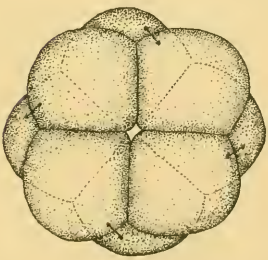

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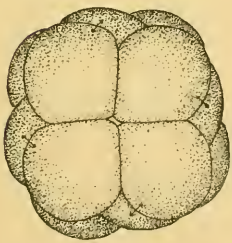

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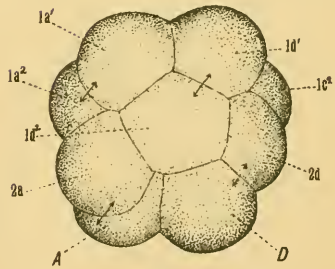

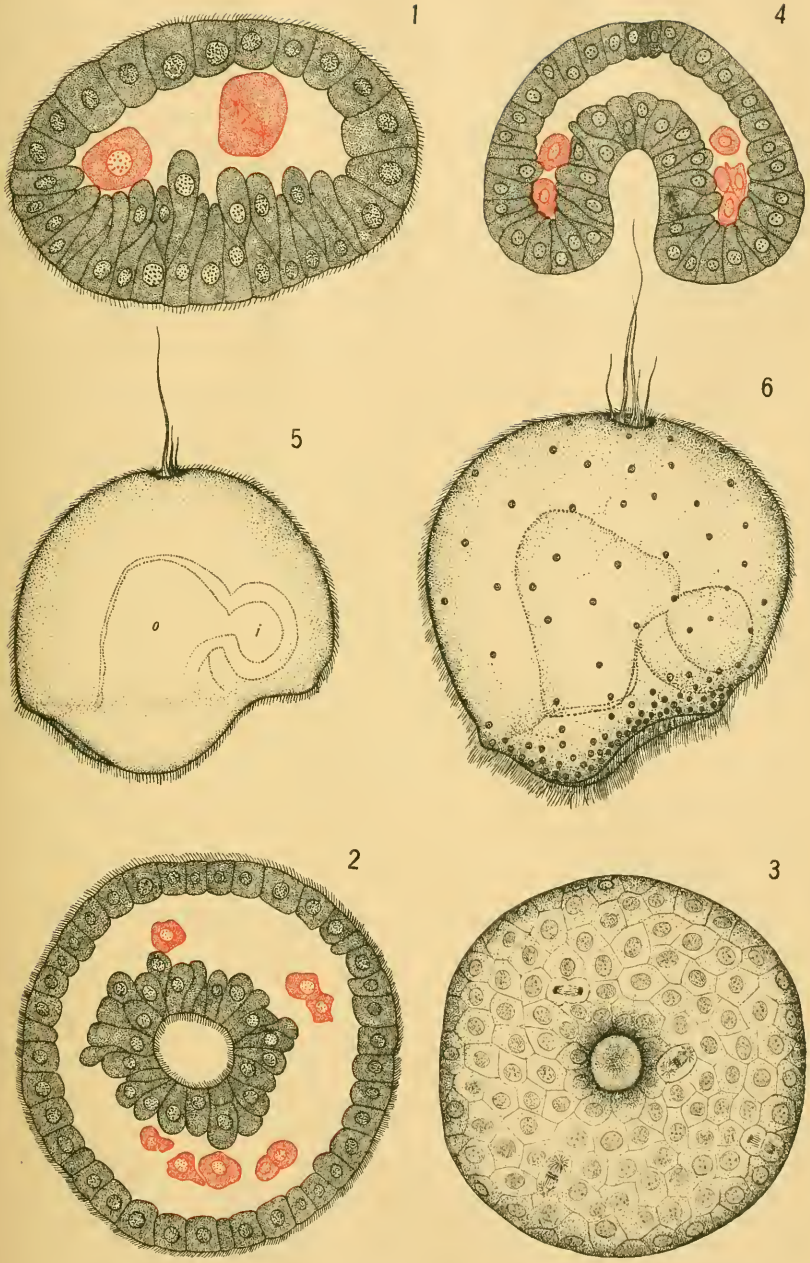
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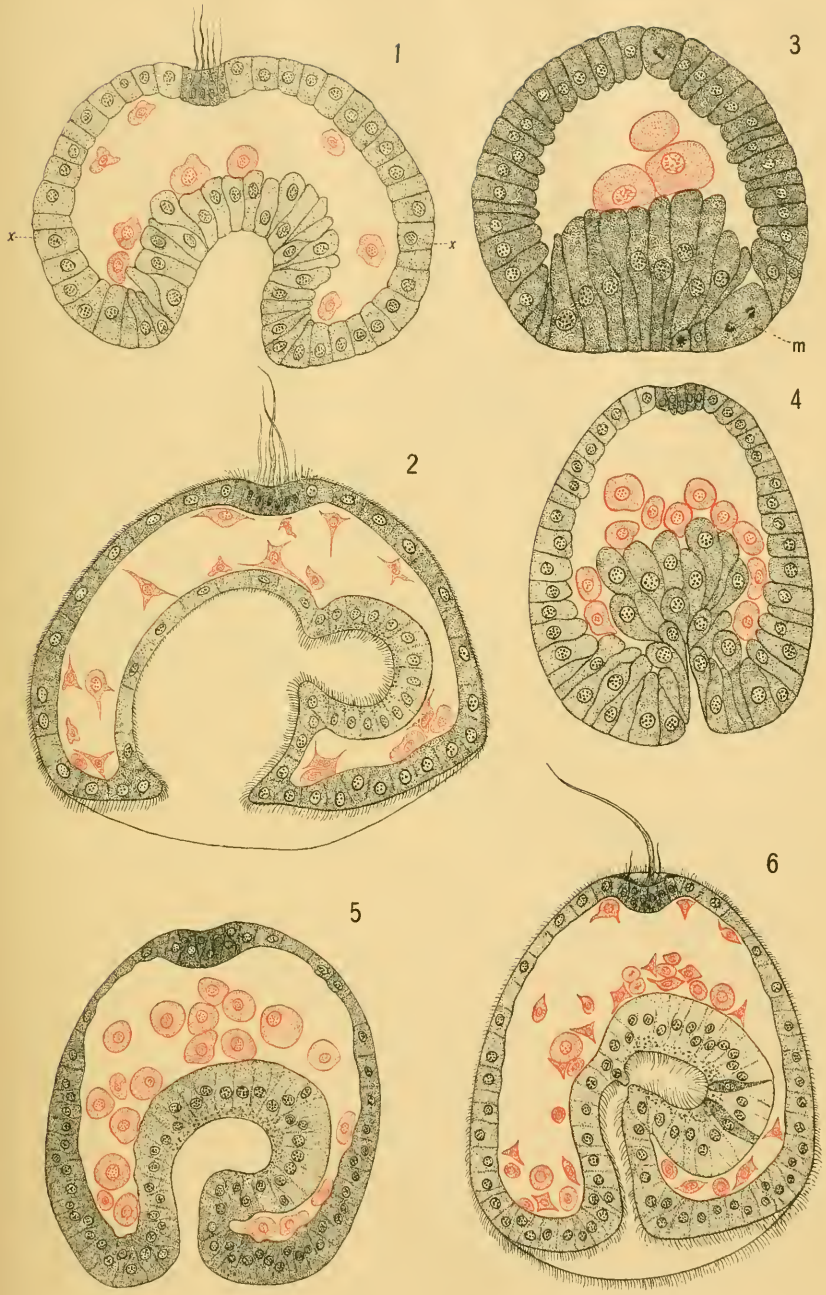
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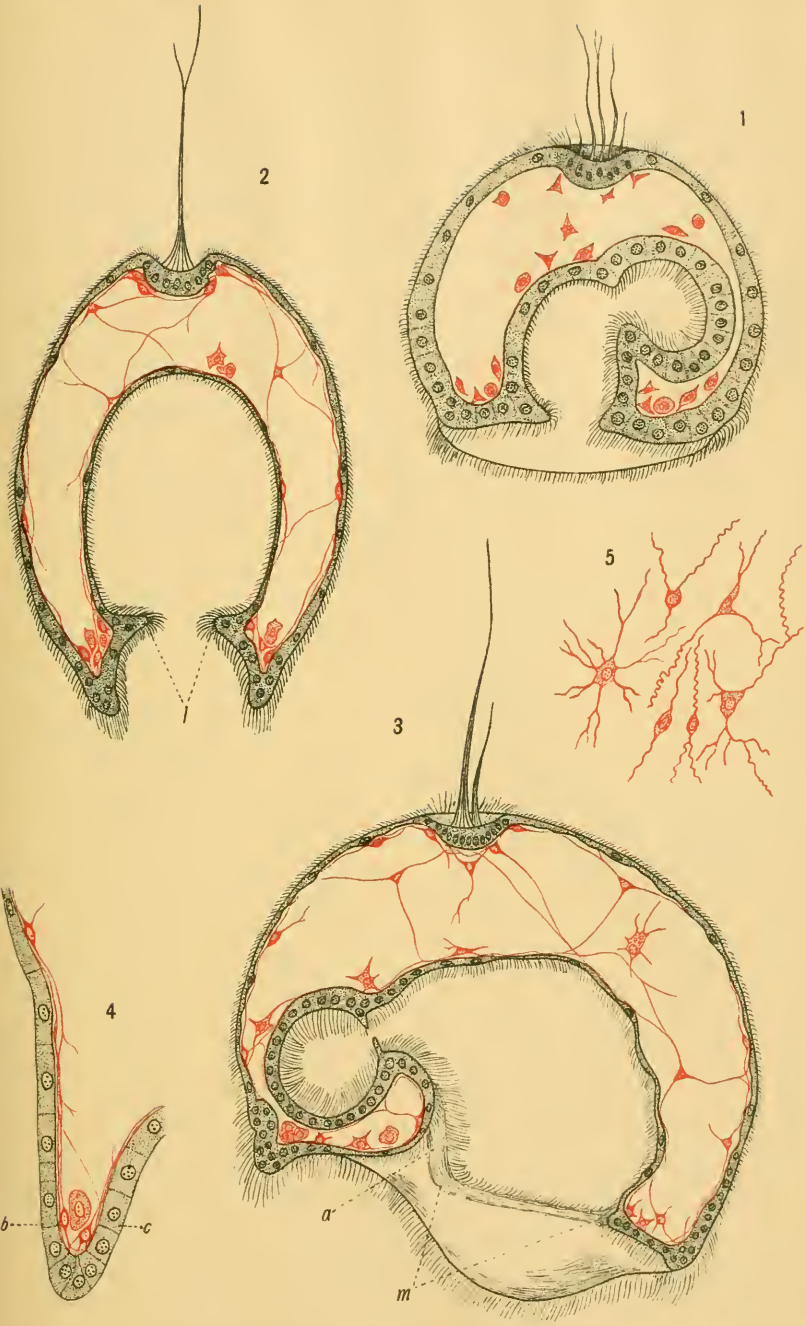
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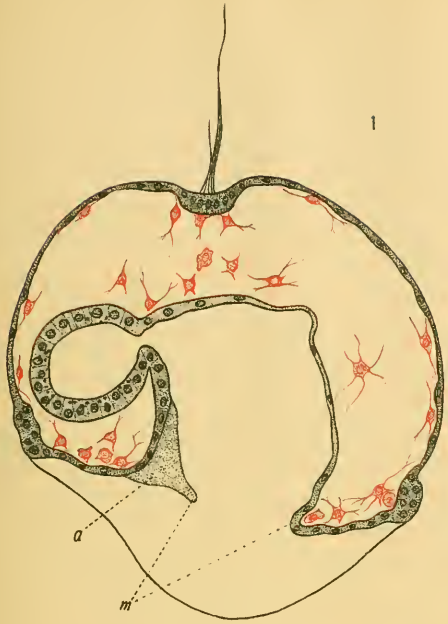

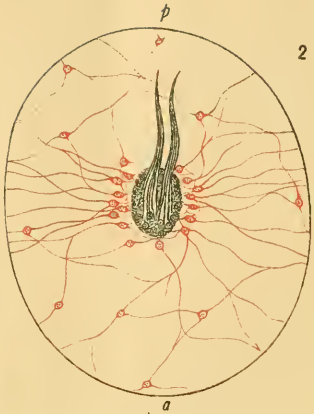

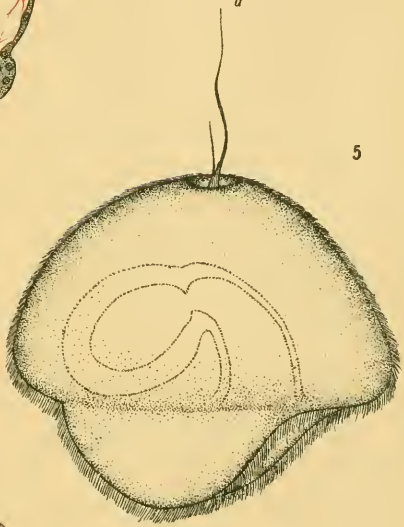

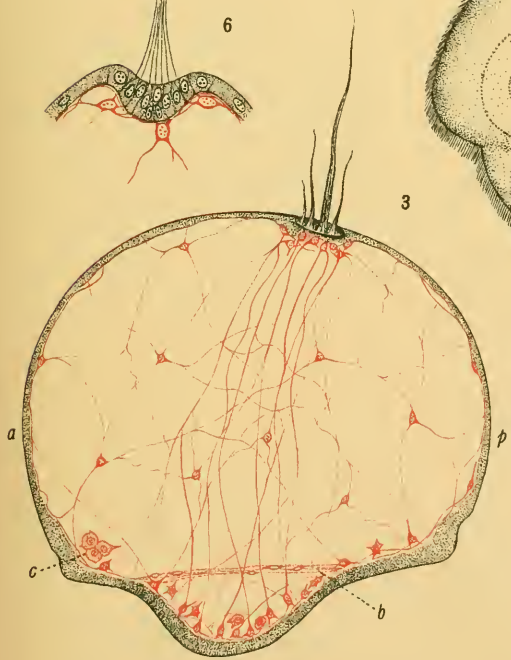

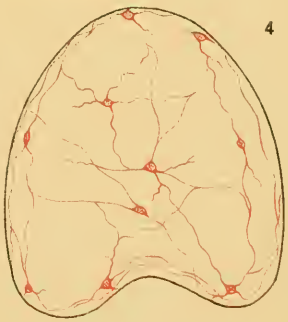

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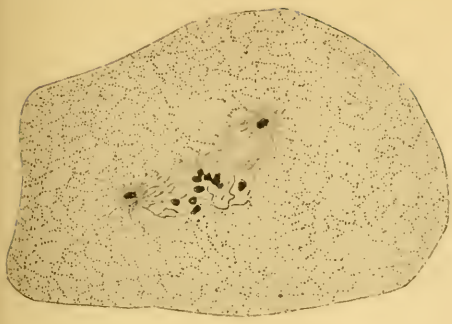

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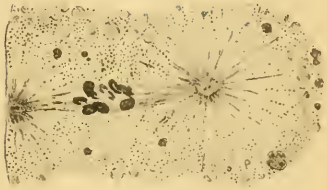

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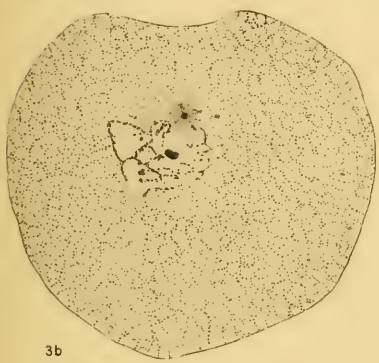

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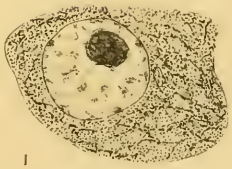

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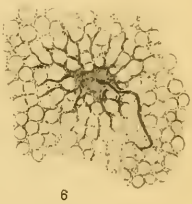

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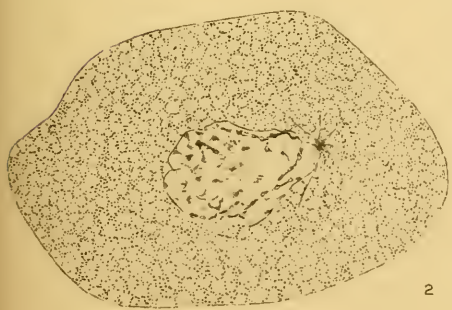

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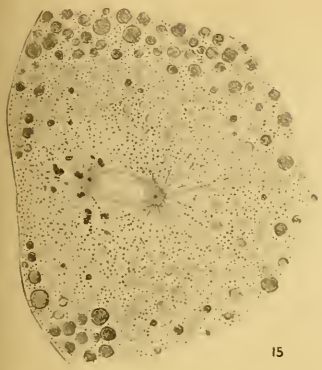

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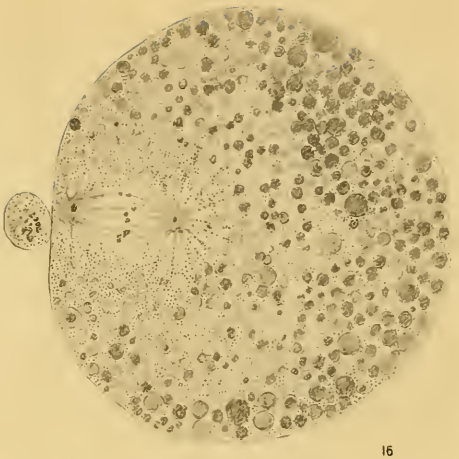

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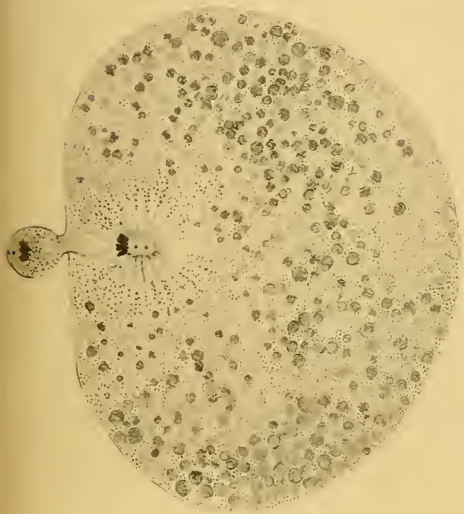

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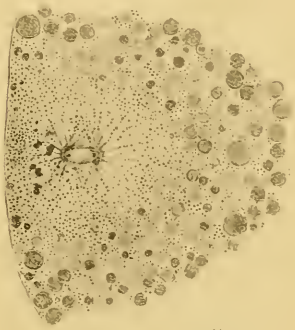

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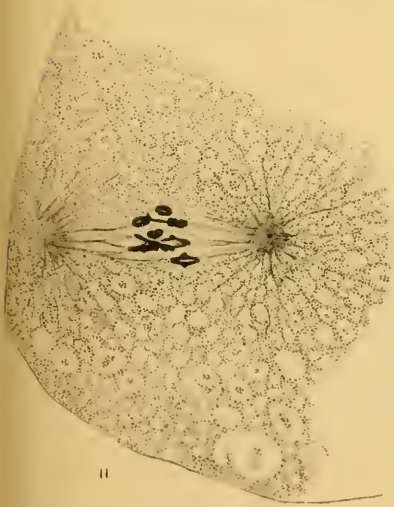

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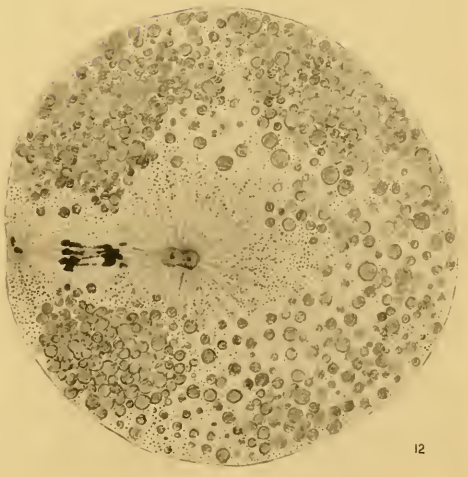

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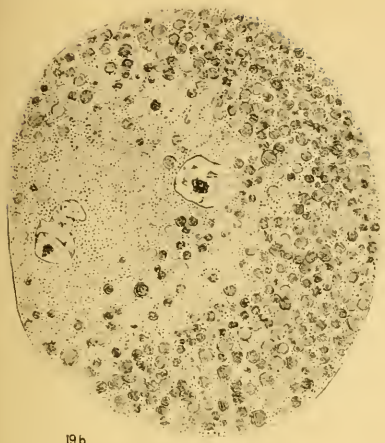

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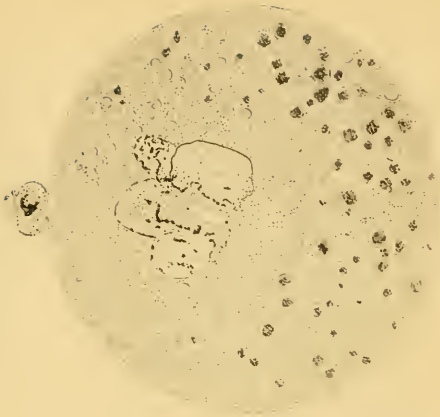

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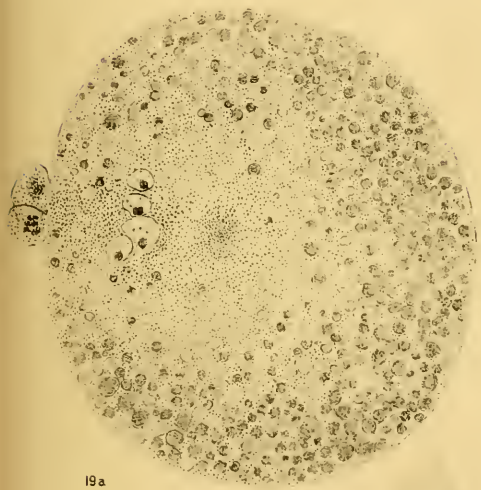

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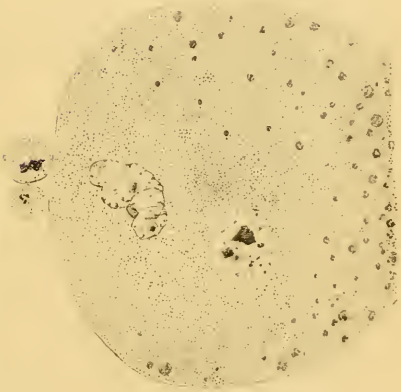

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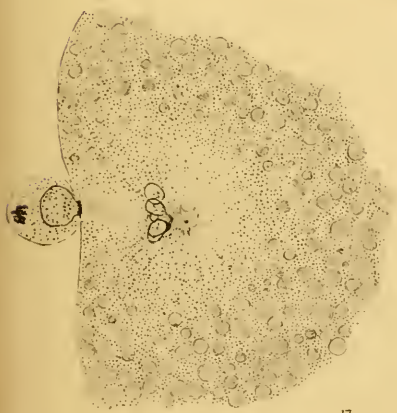

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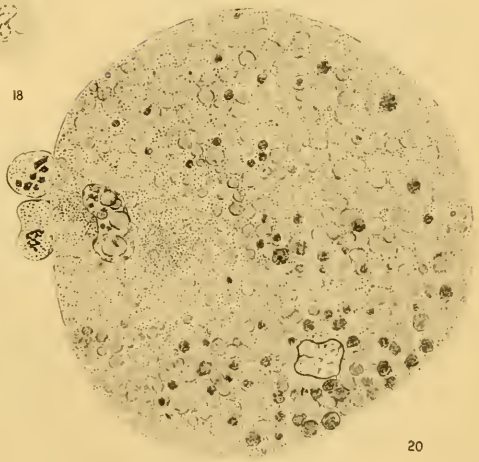

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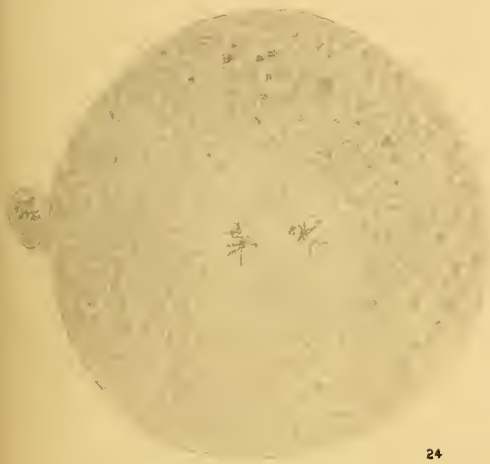

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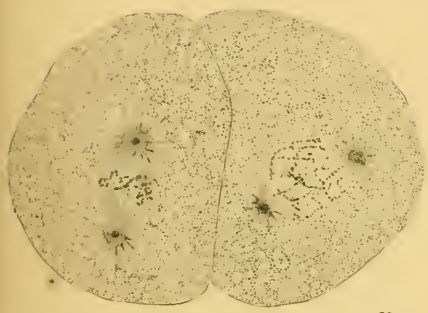

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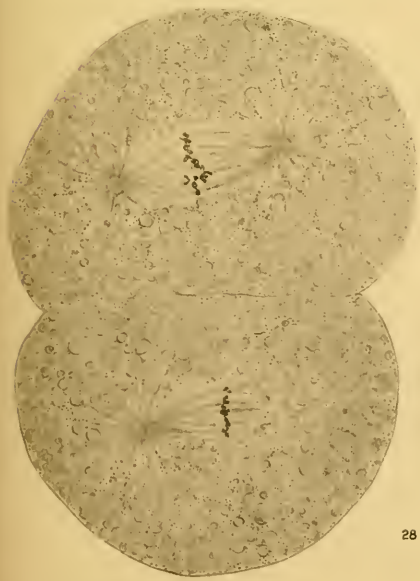

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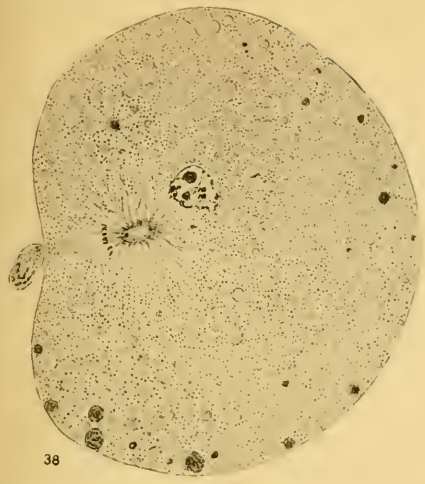
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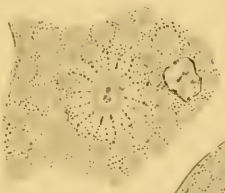
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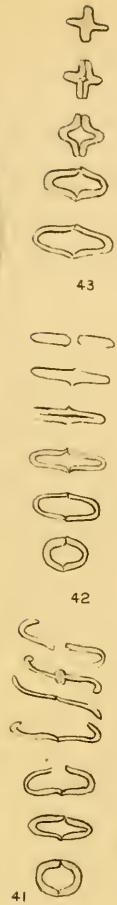
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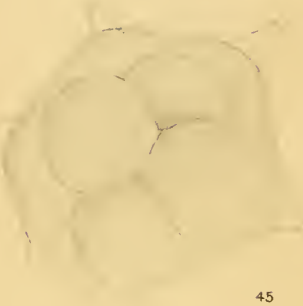
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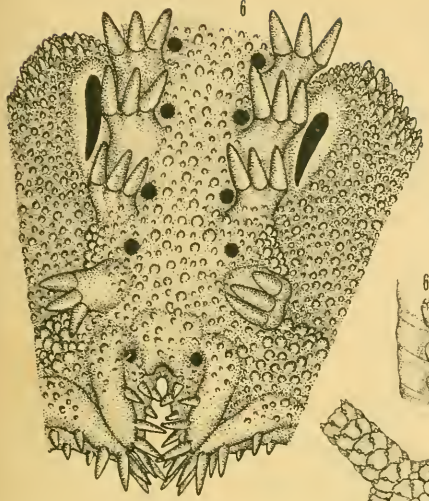
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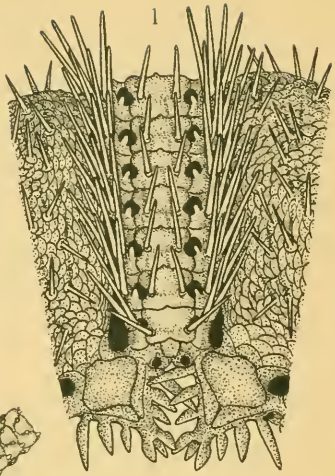
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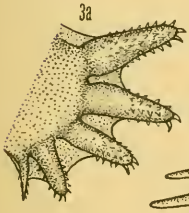
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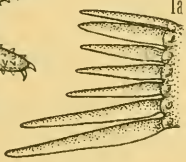
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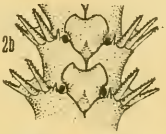
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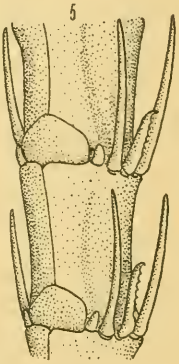
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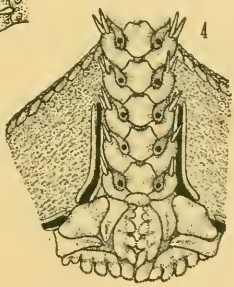
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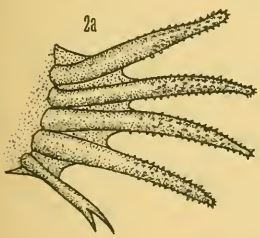
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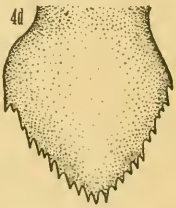
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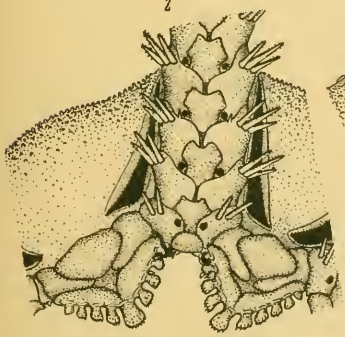
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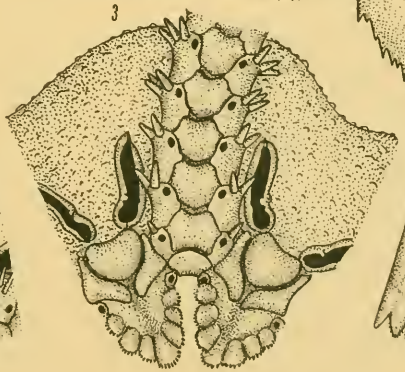
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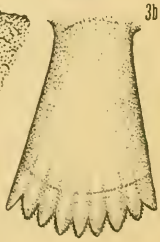
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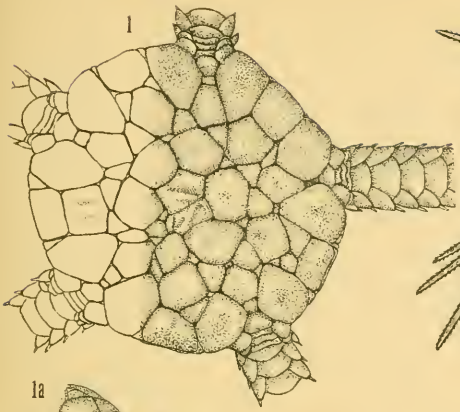
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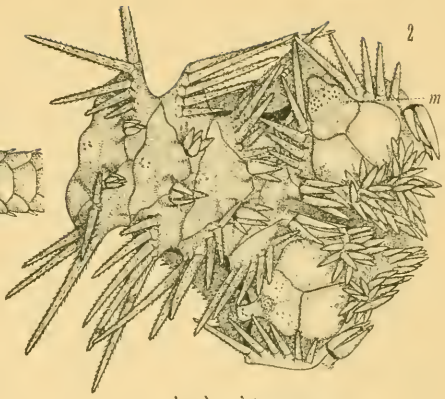
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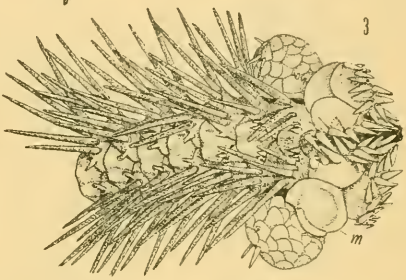
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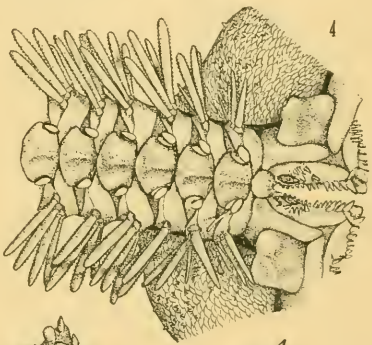
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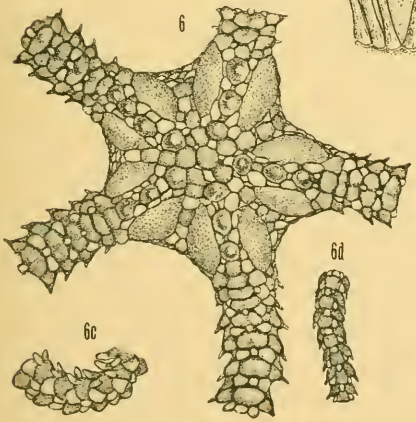
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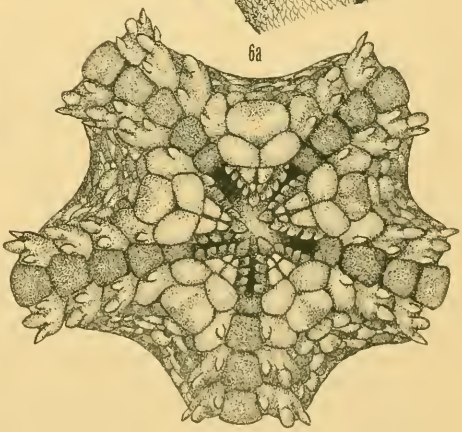
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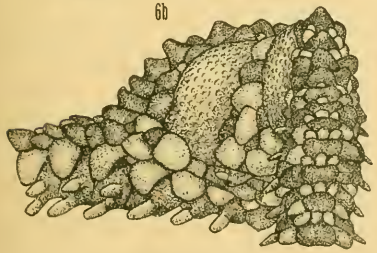
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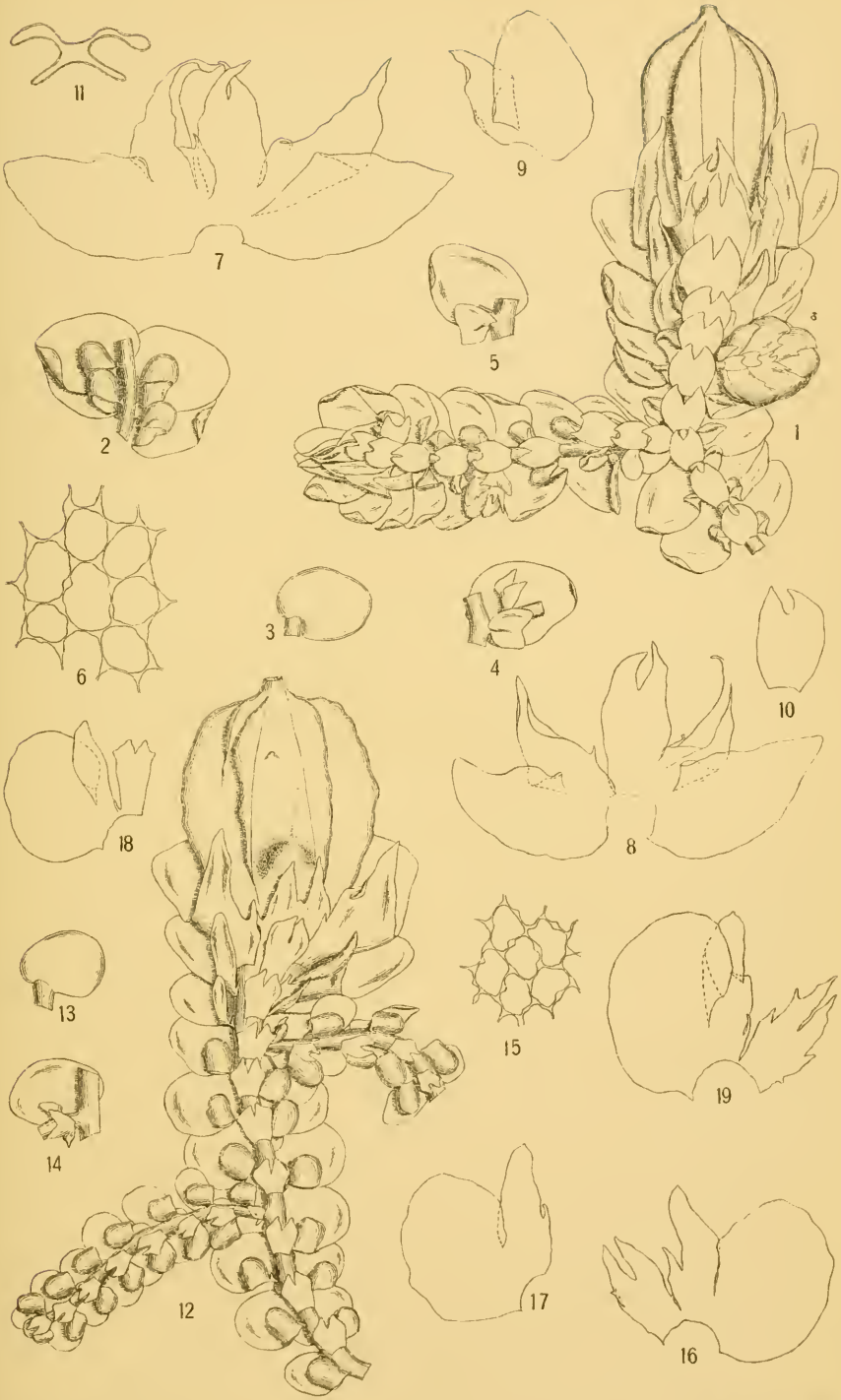
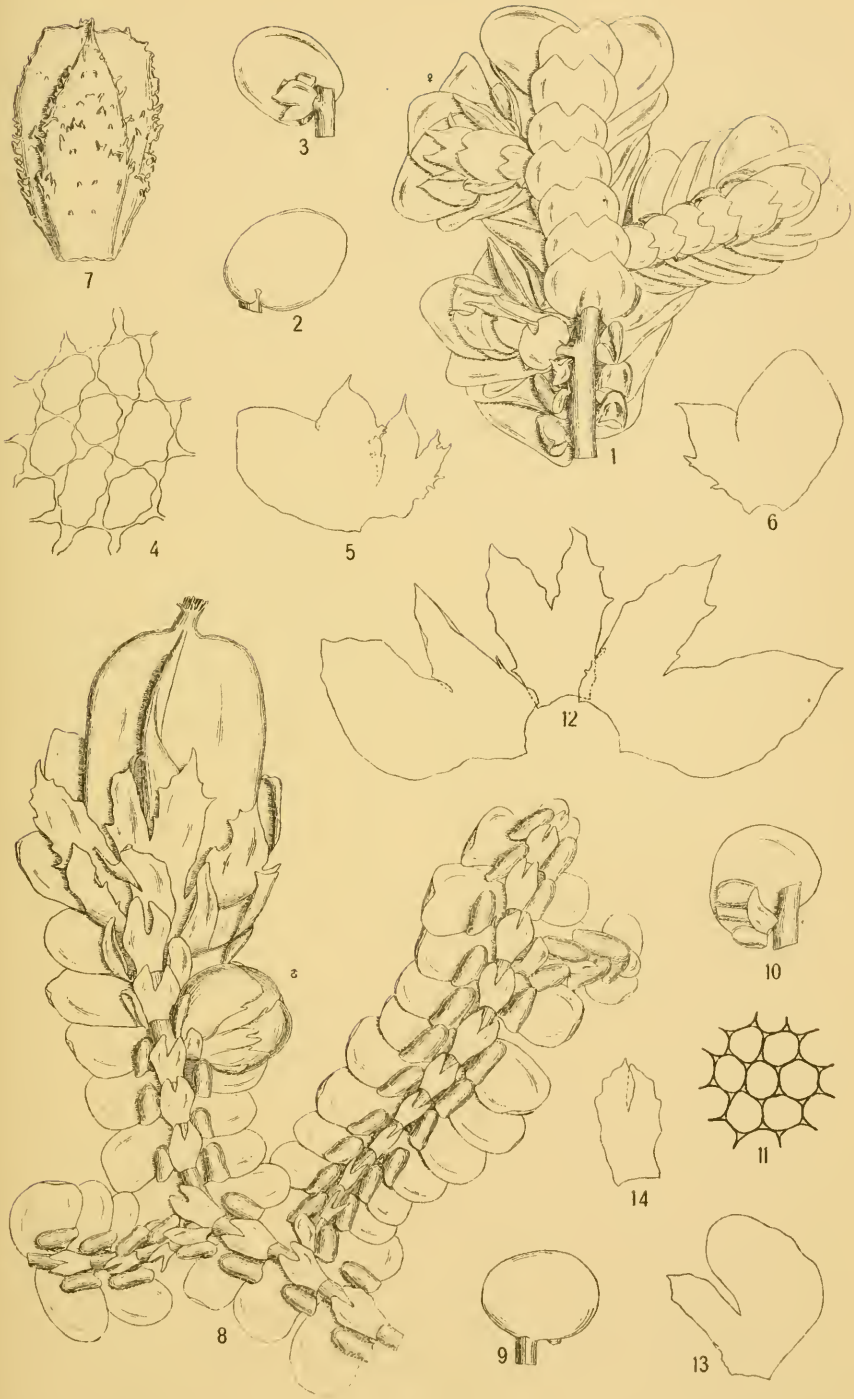


A.W.Evans from Nature

Heliotype Printing Co. Boston.

1-11. Frullania Aongstroemii Evans.

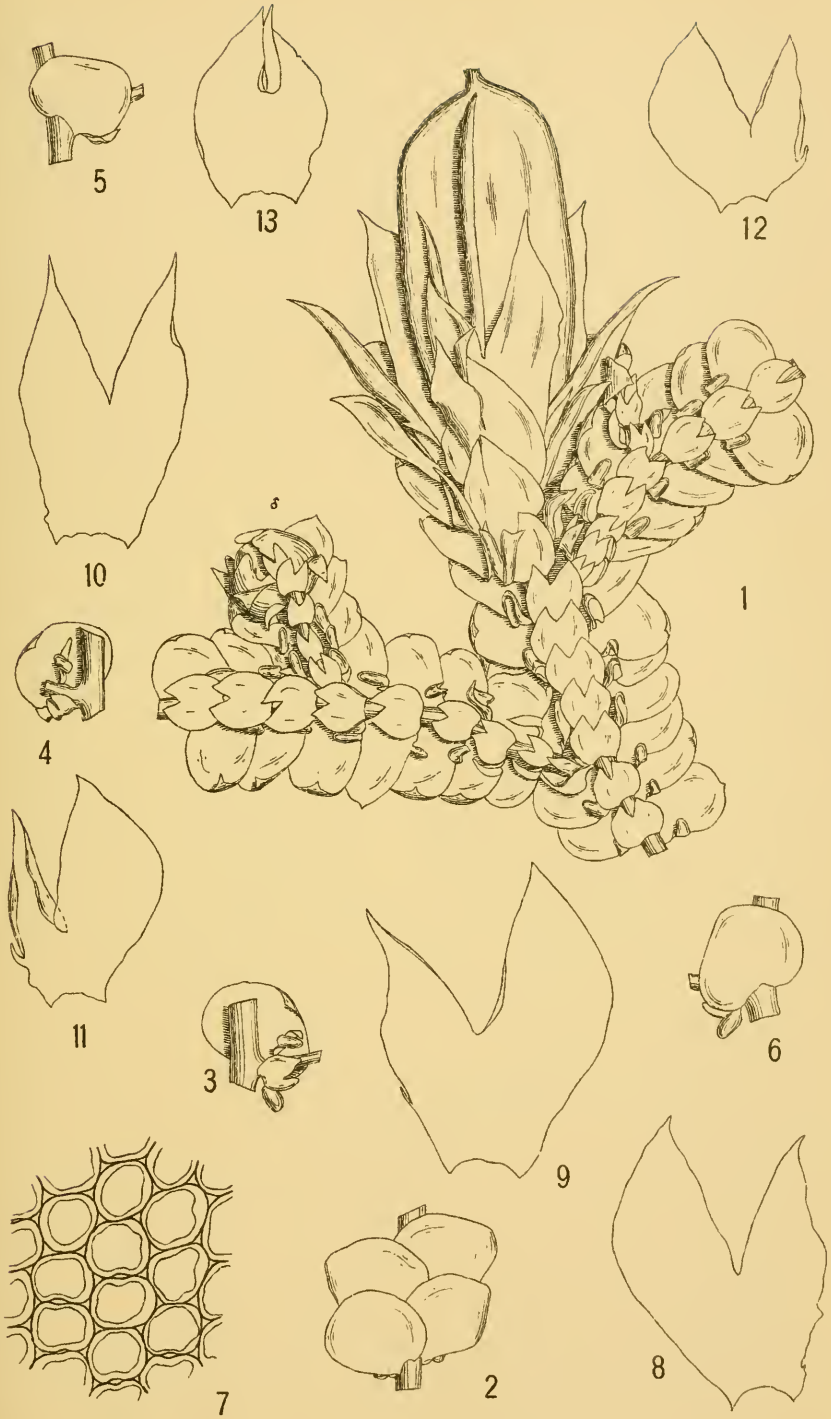
12-19. Frullania Oahuensis Hampe.



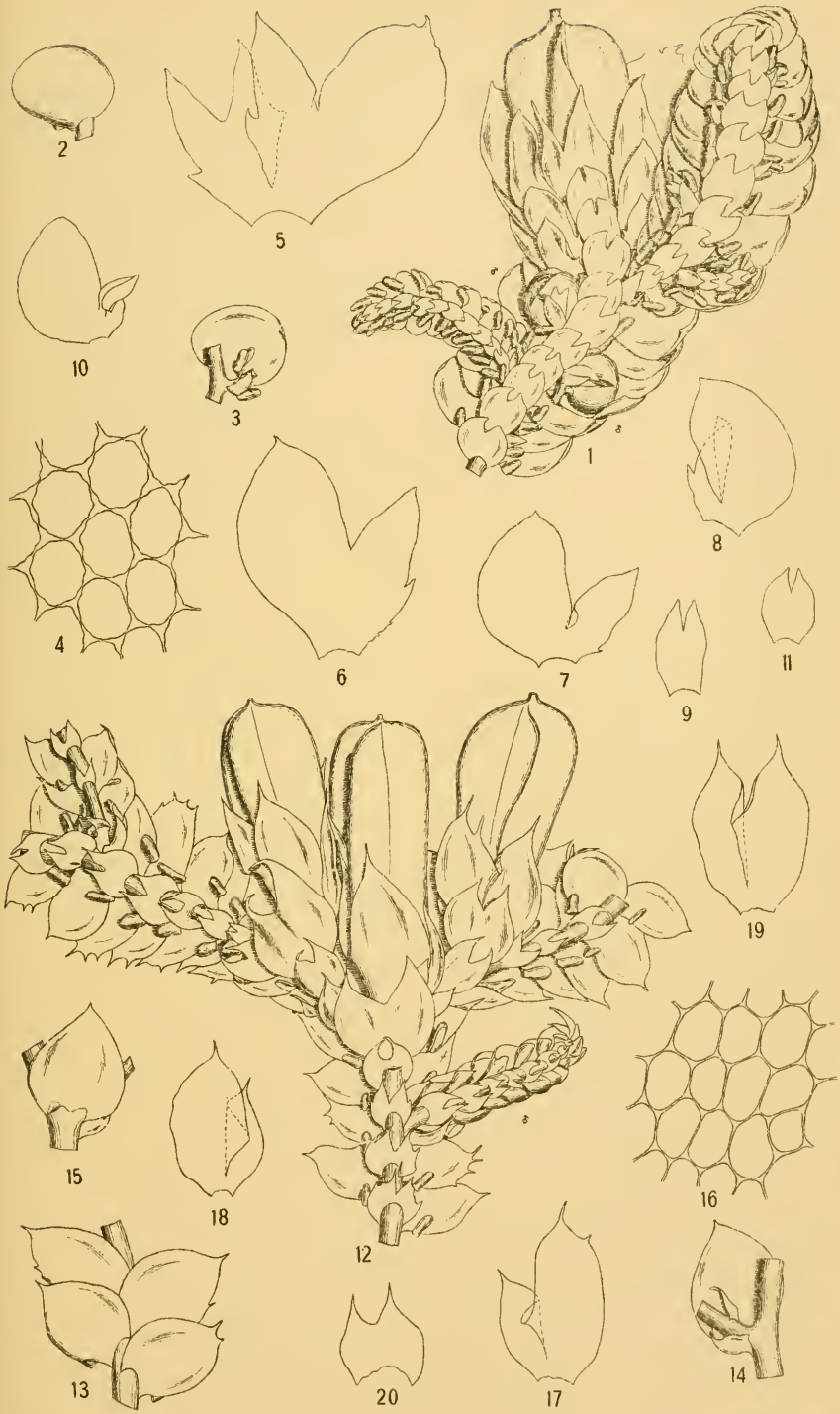
A.M. Evans, from Nature

1-7. Frullania Sandvicensis Angstr.

8-14. Frullania Meyeniana Lindenb.



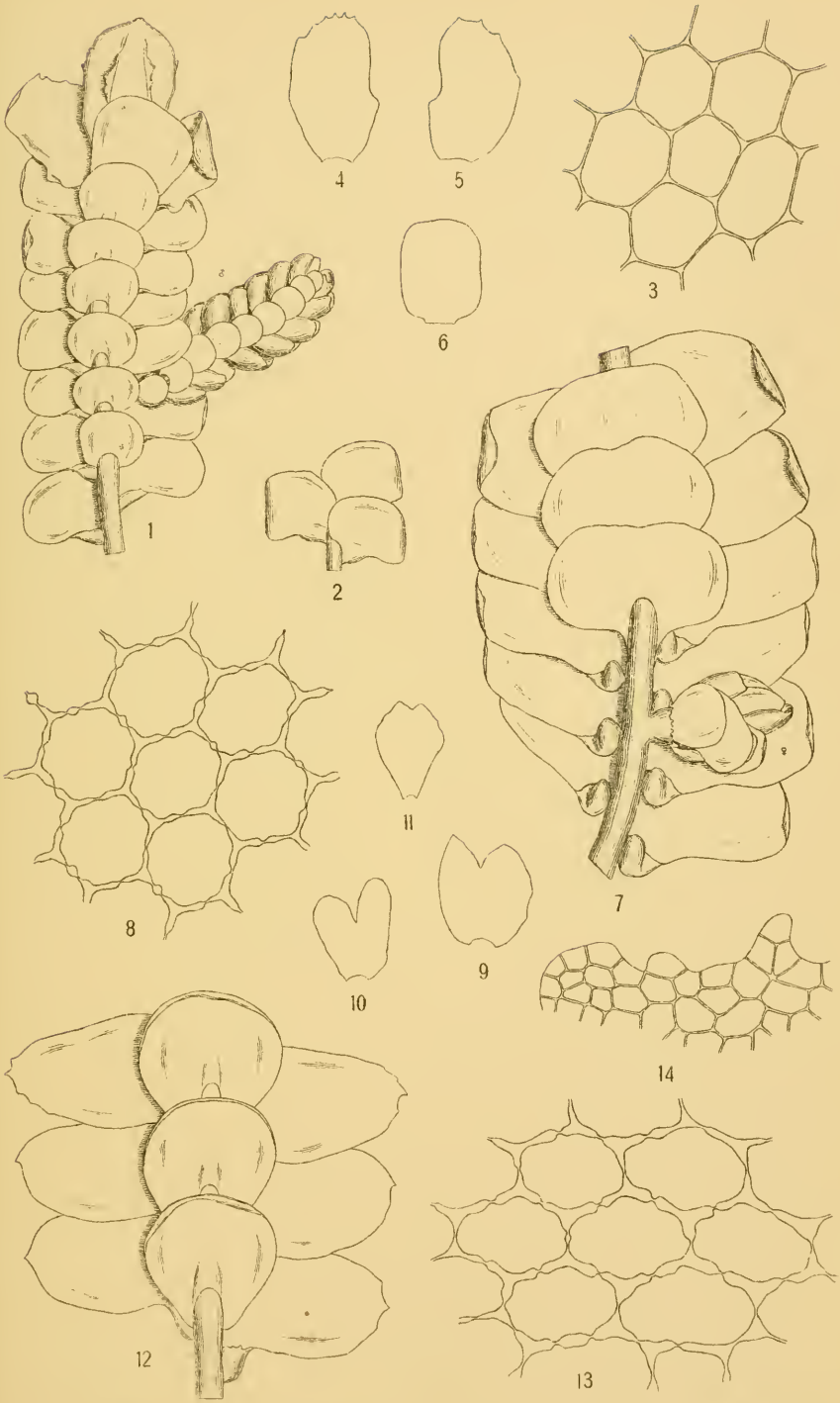
Frullania apiculata (R. Bl. and Nees) Dumort.



A.M. Evans, Jr. in Nature

1-11. Frullania hypoleuca Nees

12-20. Jubula piligera (Aust.) Evans.



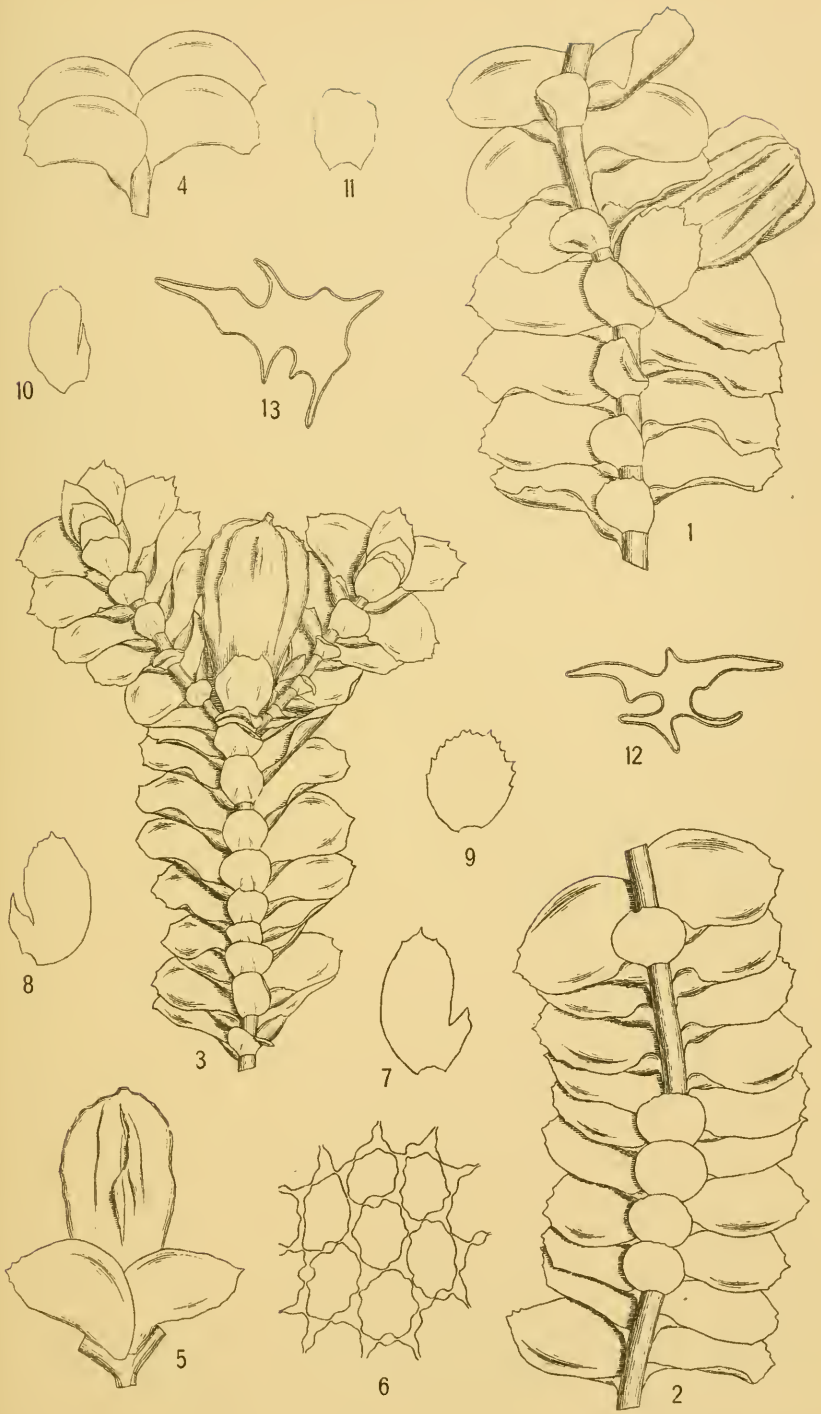
A.M.Evans, from Nature

Heliotype Printing Co.Boston

1-6. Lopholejeunea subnuda (Mitt.) Steph.

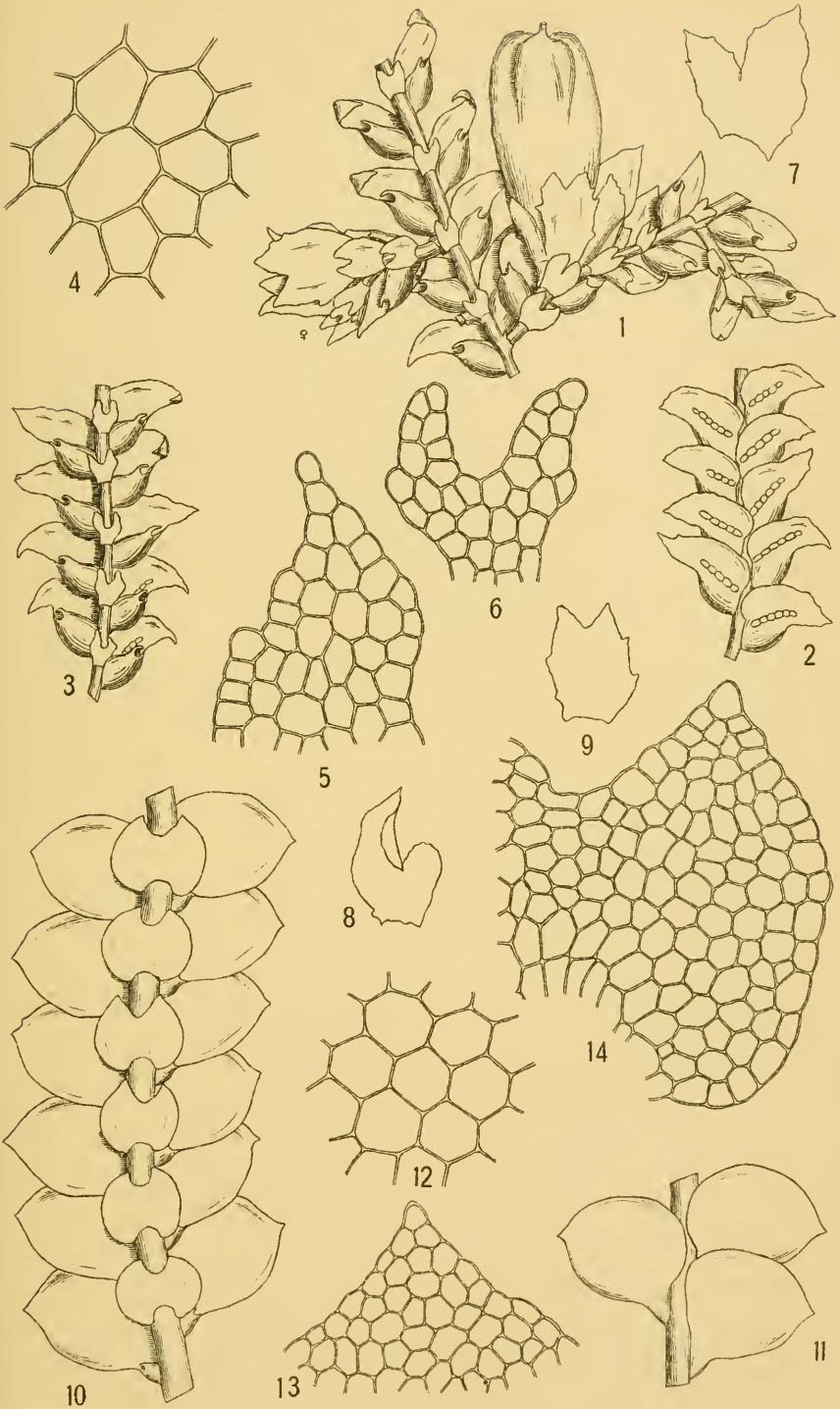
7-11. Platylejeunea baccifera (Tayl.) Steph.

12-14. Marchesinia Mittenii Evans.



A.W.Evans, from Nature.

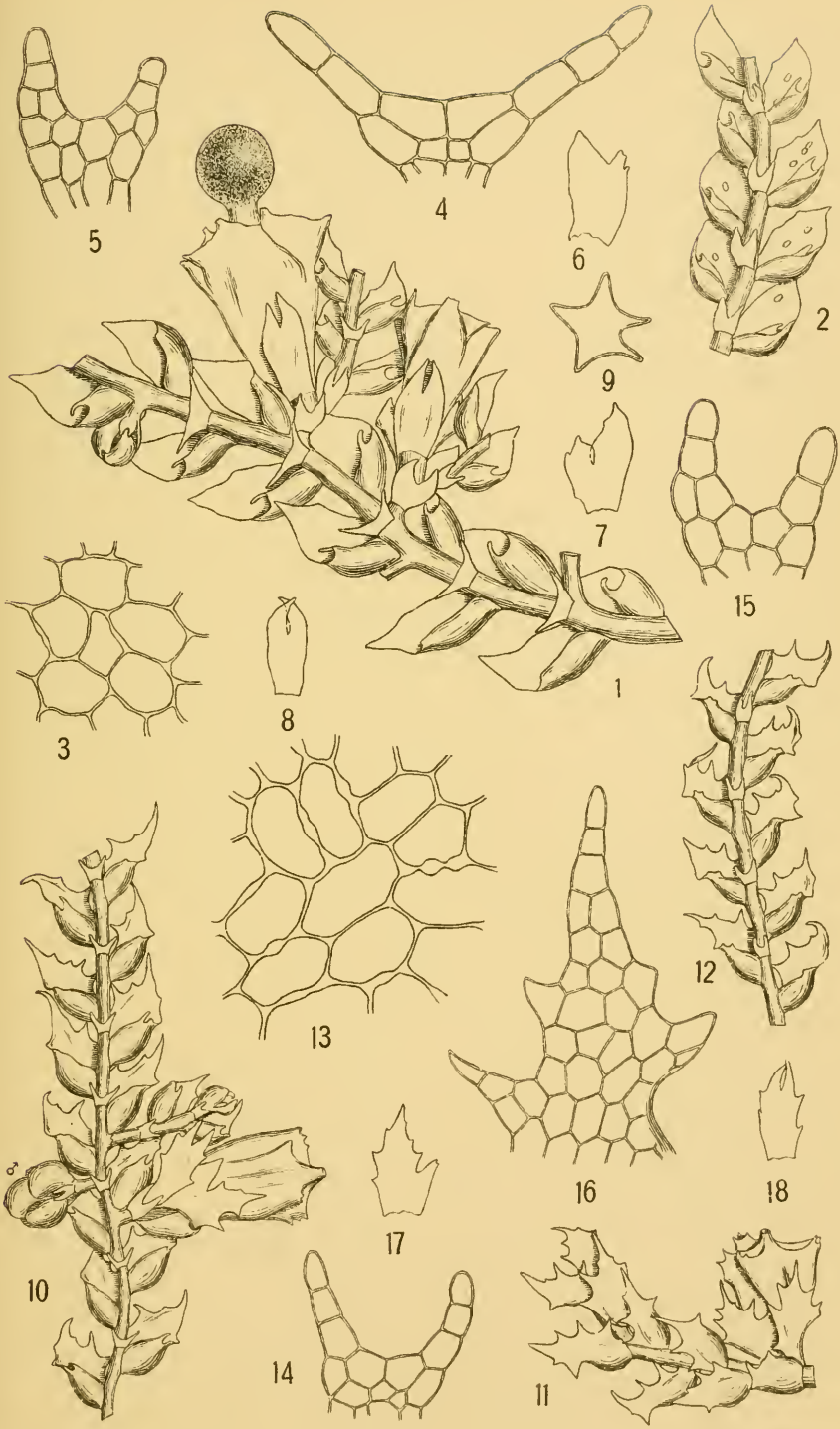
THYSANANTHUS ELONGATUS (Aust.) Evans.



Heliotype Printing Co. Boston

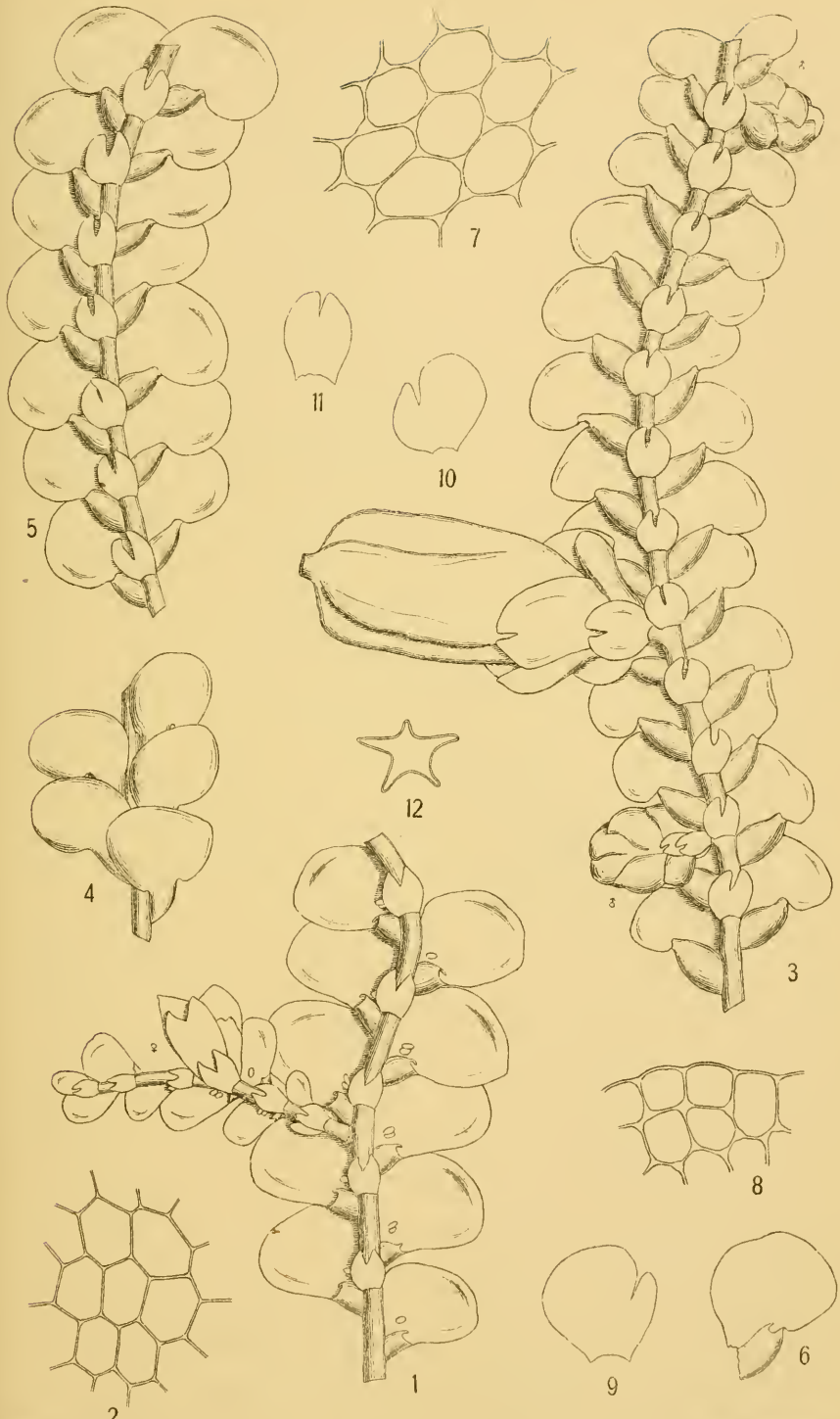
1-9. HARPALEJEUNEA PSEUDONEURA Evans.

10-14. HARPALEJEUNEA OWAIHIENSIS (Gottsche) Evans.



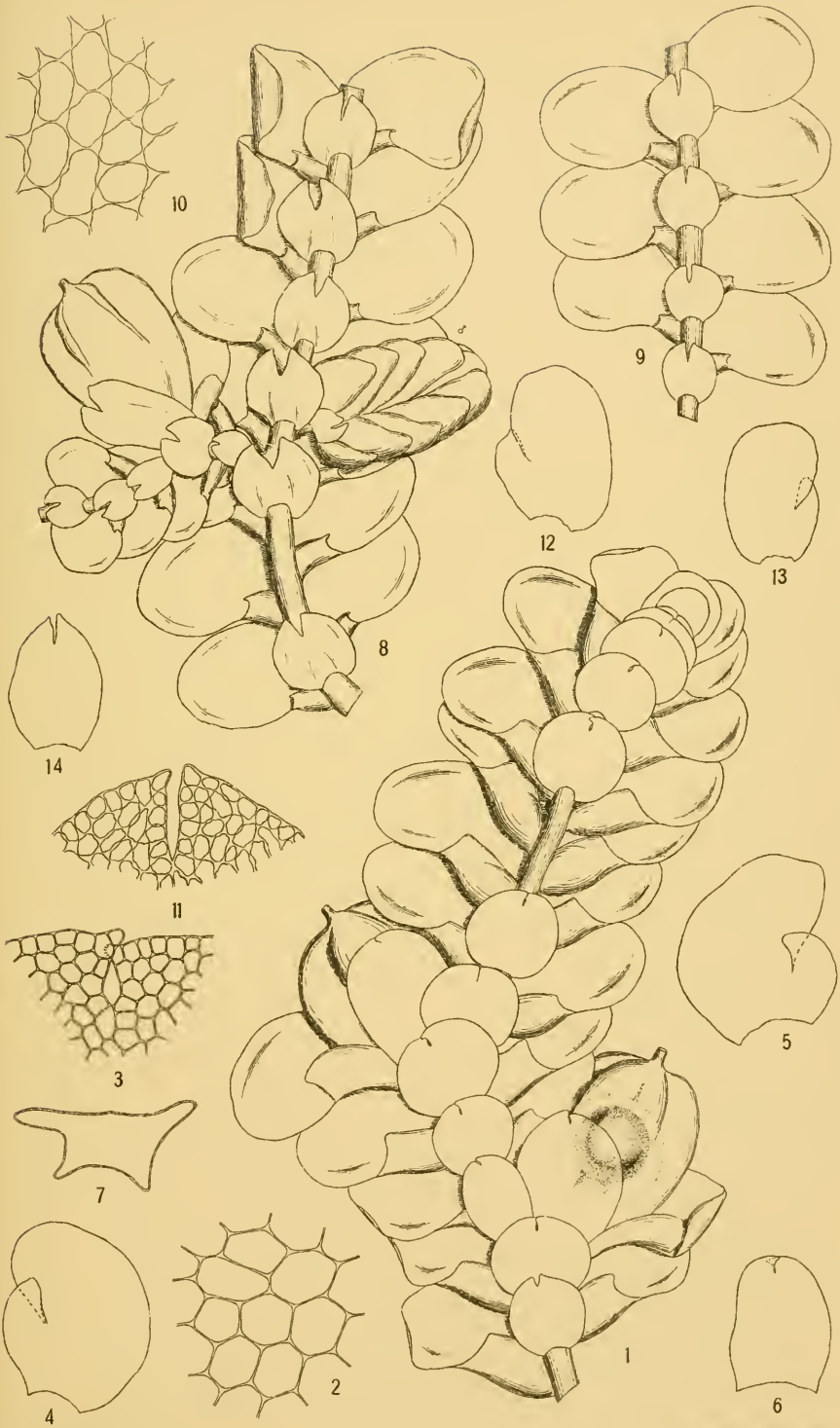
1-9. Drepanolejeunea Anderssonii (Ångstr.) Evans.

10-18. Drepanolejeunea uncinata (Mitt.) Steph.



1-2. Ceratolejeunea oculata (Gottsche) Steph.

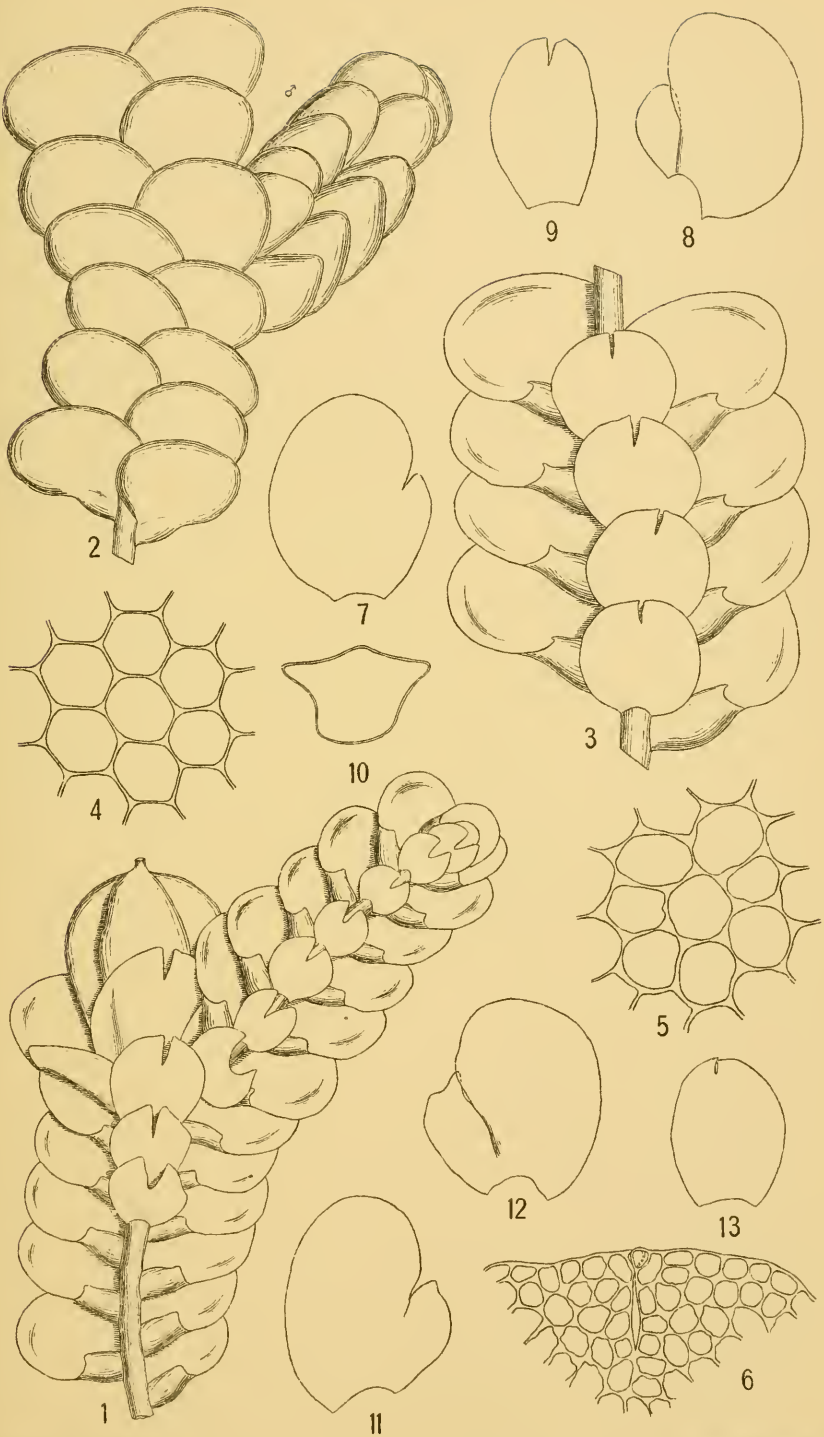
3-12. Trachylejeunea Oahuensis Evans.



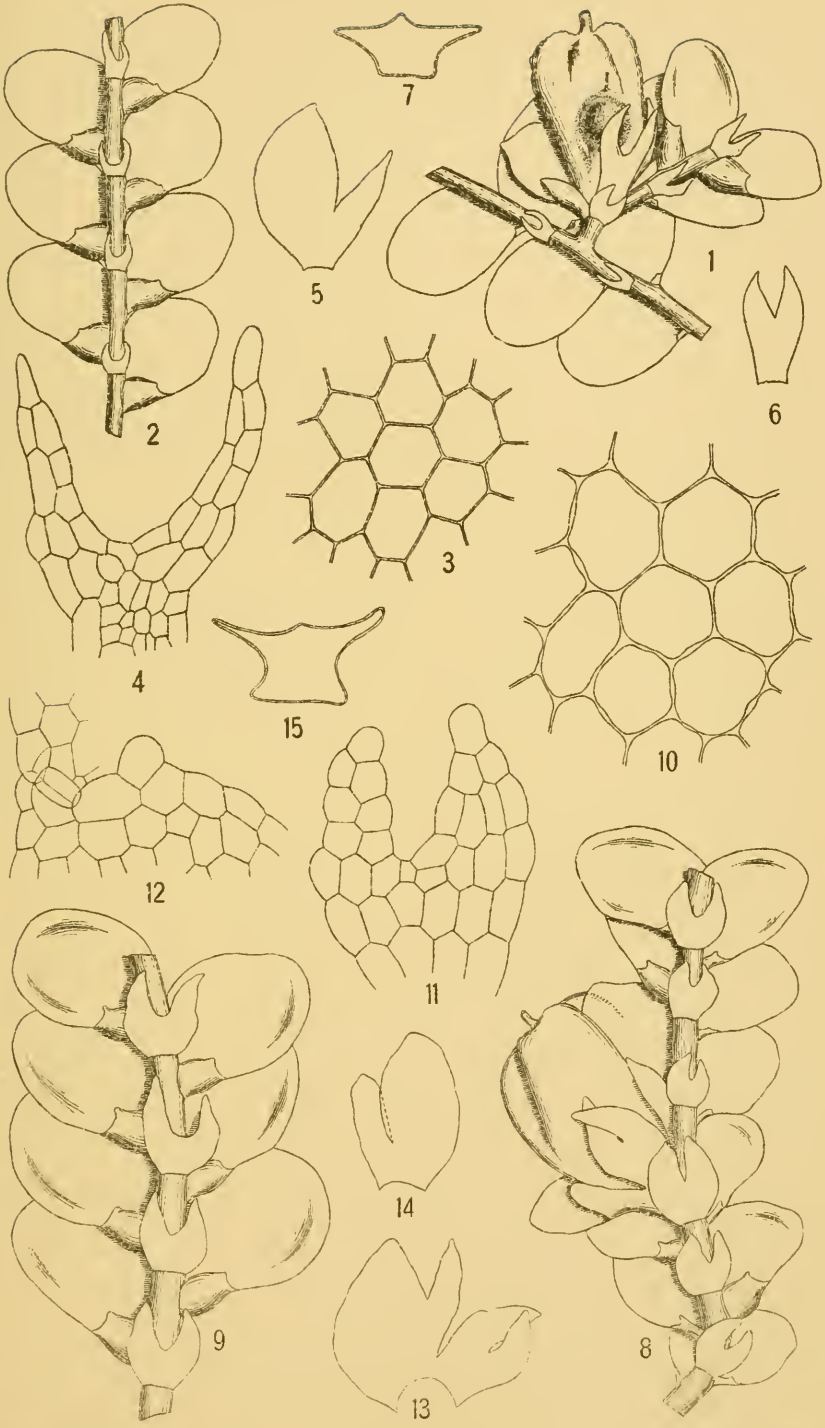
A.W.Evans, from Nature.

1-7. Cheilolejeunea stenoschiza (Åugstr.) Evans.

8-14. Cheilolejeunea Hawaica Steph.

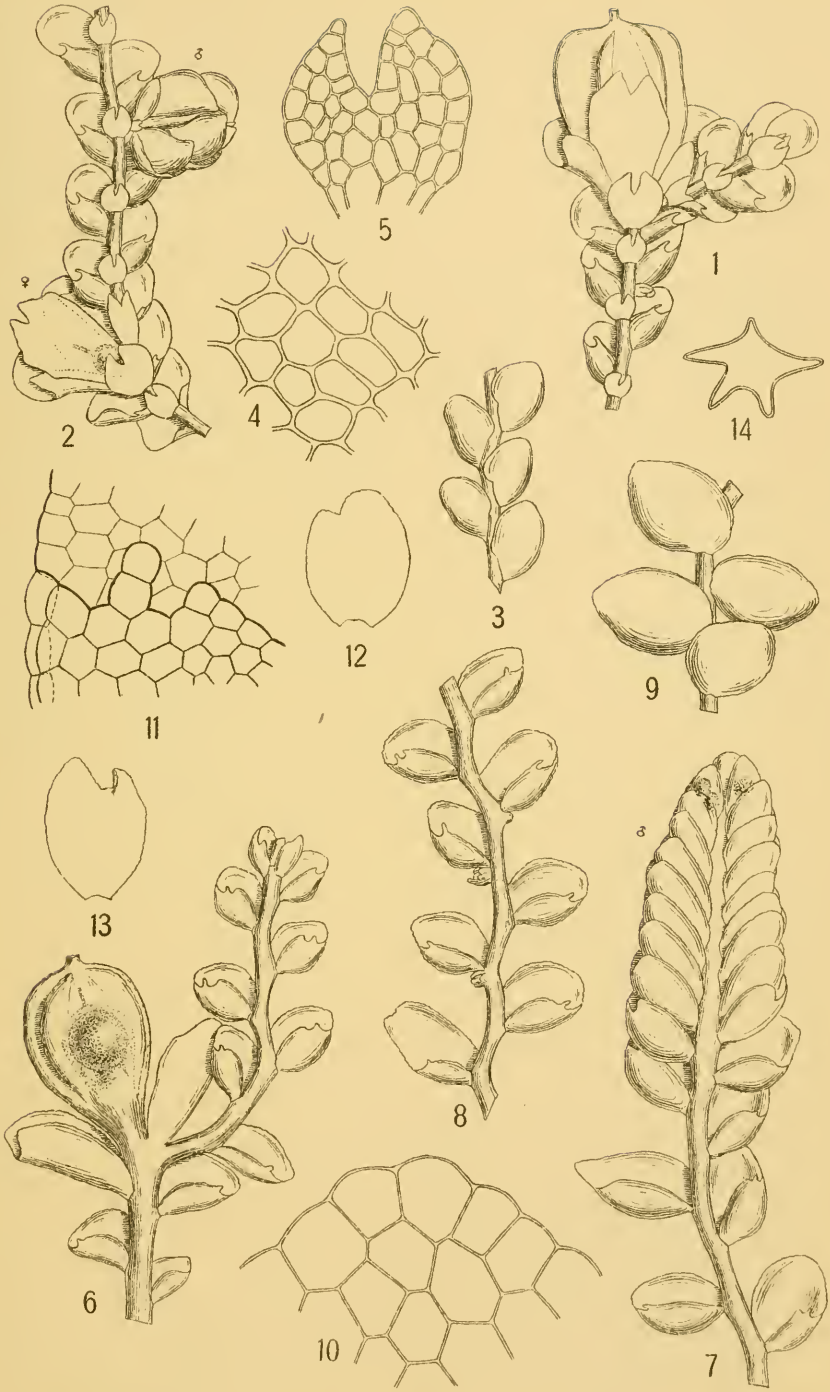


CHEILOLEJEUNEA INTERTEXTA (Lindenb.) Steph.



1-7. Lejeunea Pacifica Mont.

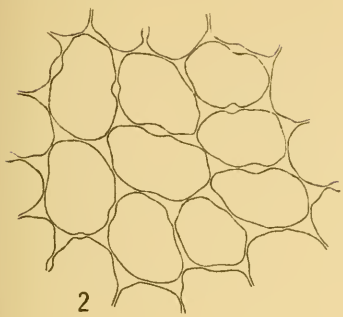
8-15. Lejeunea anisophylla Mont.



A.W. Evans from Nature. Bureau Printing & Binding

1-5. MICROLEJEUNEA ALBICANS (Nees) Jack and Steph.

6-14. COLOLEJEUNEA COOKEI Evans.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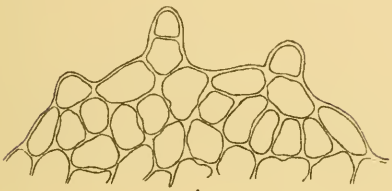
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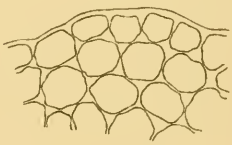
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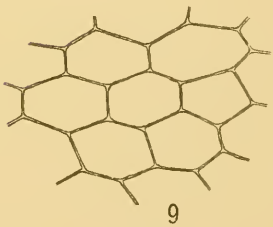
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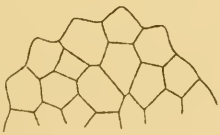
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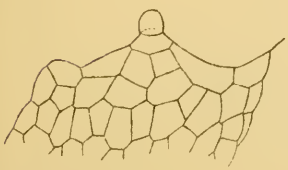
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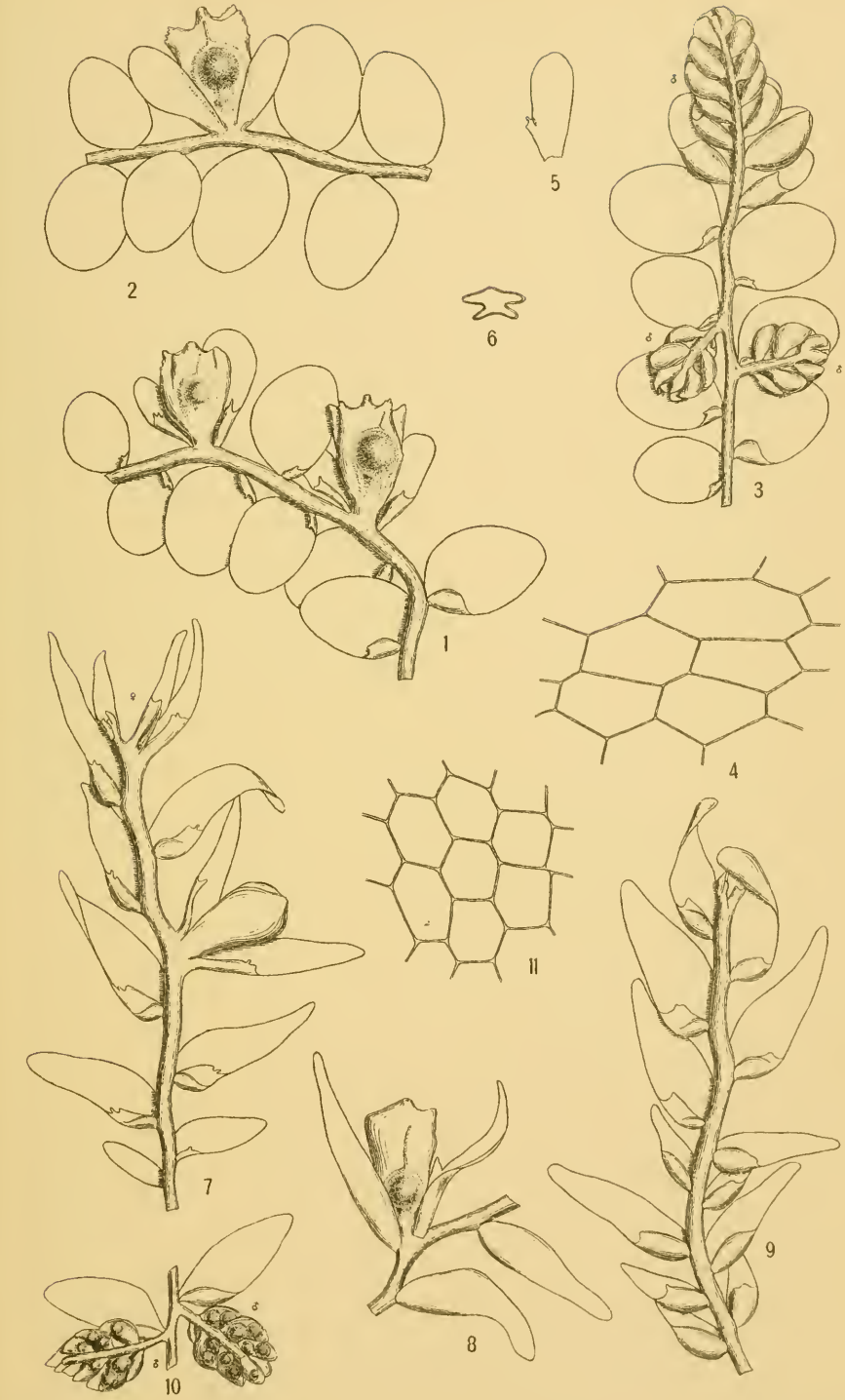
A.W.Evans, from Nature.

1-6. COLOLEJEUNEA OBCORDATA (Aust.) Evans.

7-13. COLOLEJEUNEA CEATOCARPA (Ångstr.) Steph.

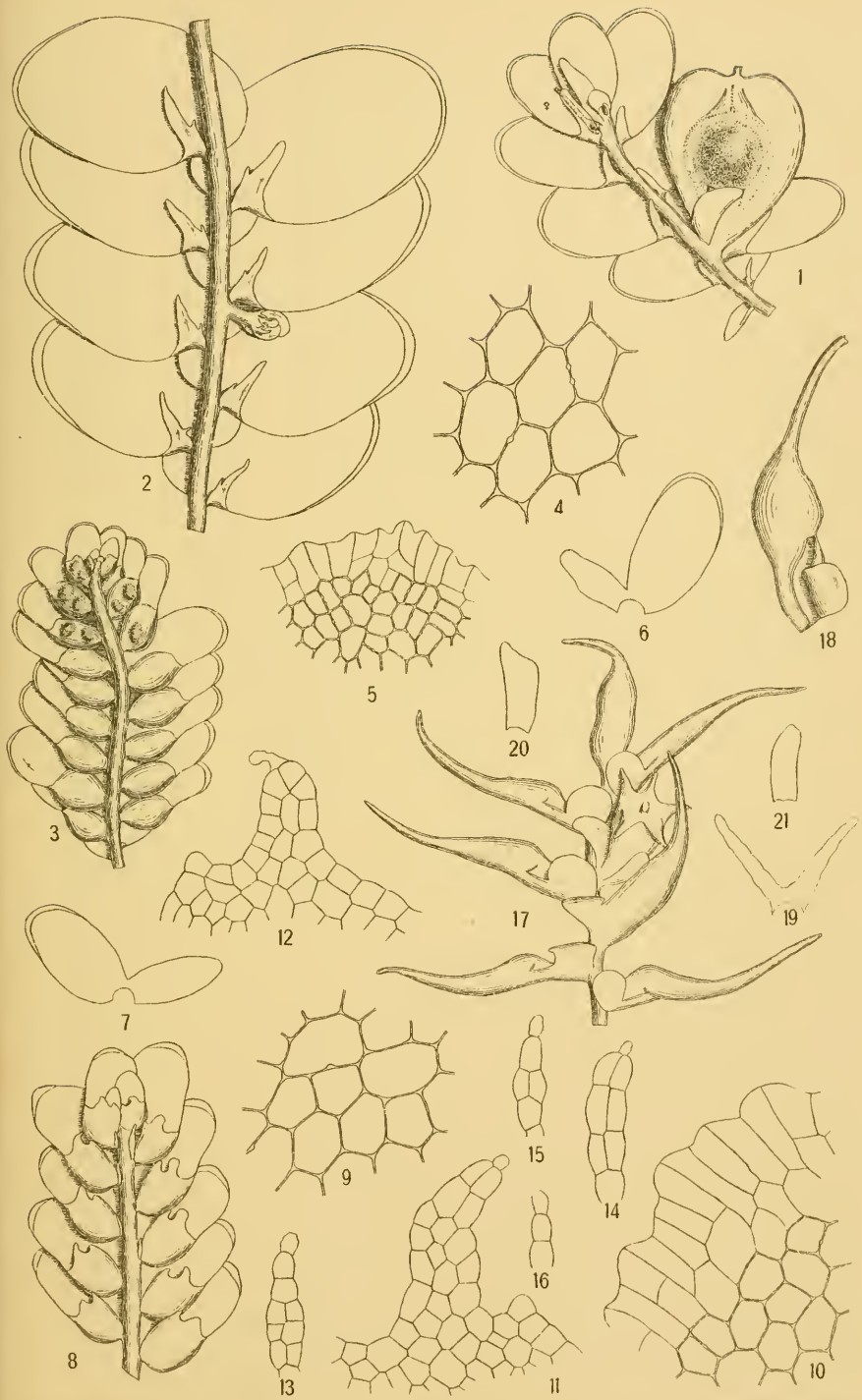


A.W.Evans, from Journ.

Heliotype Printing Co.Boston

1-6. COLOLEJEUNEA OVALIFOLIA Evans.

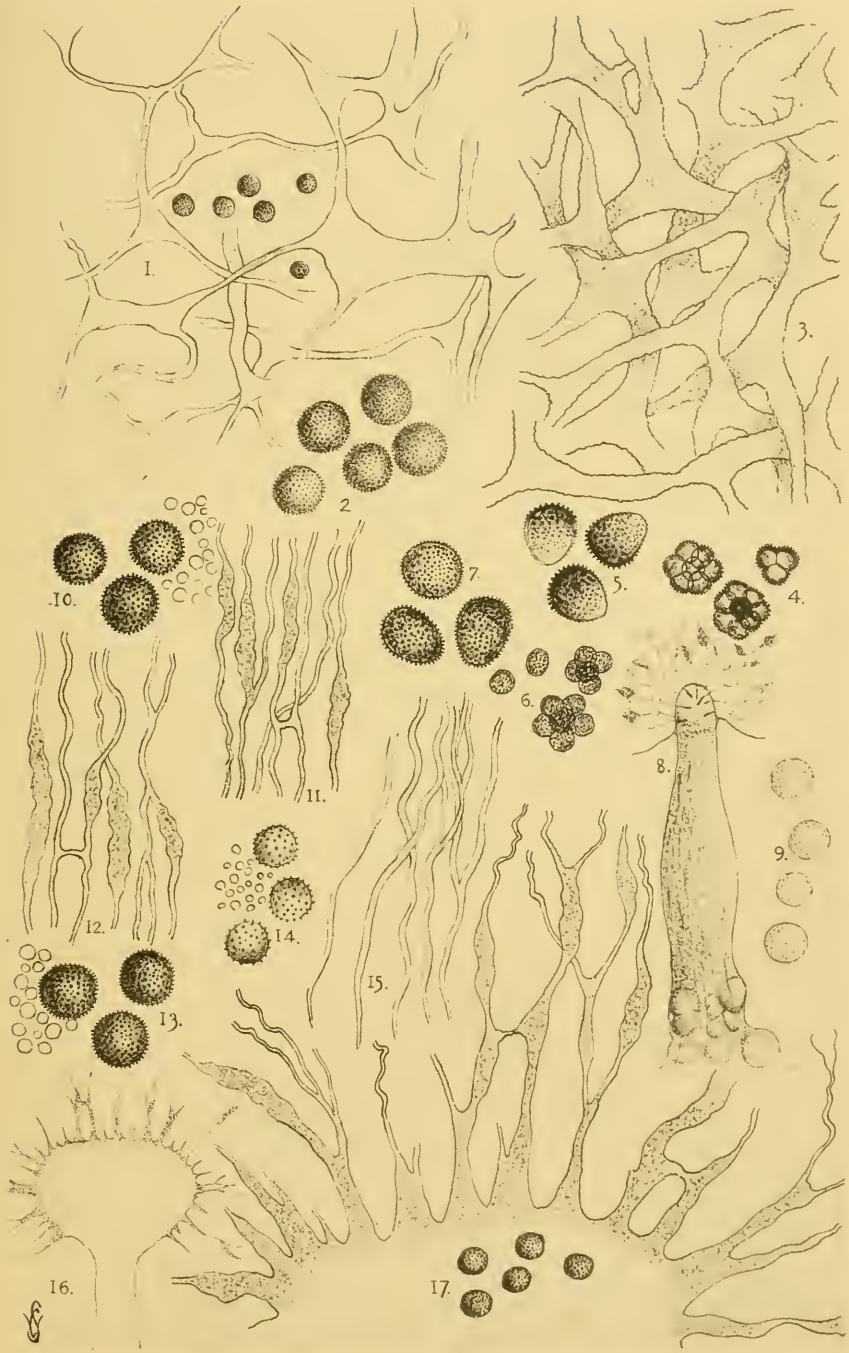
7-11. COLOLEJEUNEA HILLEBRANDII (Aust.) Steph.



1-7. COLOLEJEUNEA LANCILOBA Steph.

8-16. COLOLEJEUNEA LONGISTYLIS Evans.

17-21. COLUROLEJEUNEA TENUICORNIS Evans.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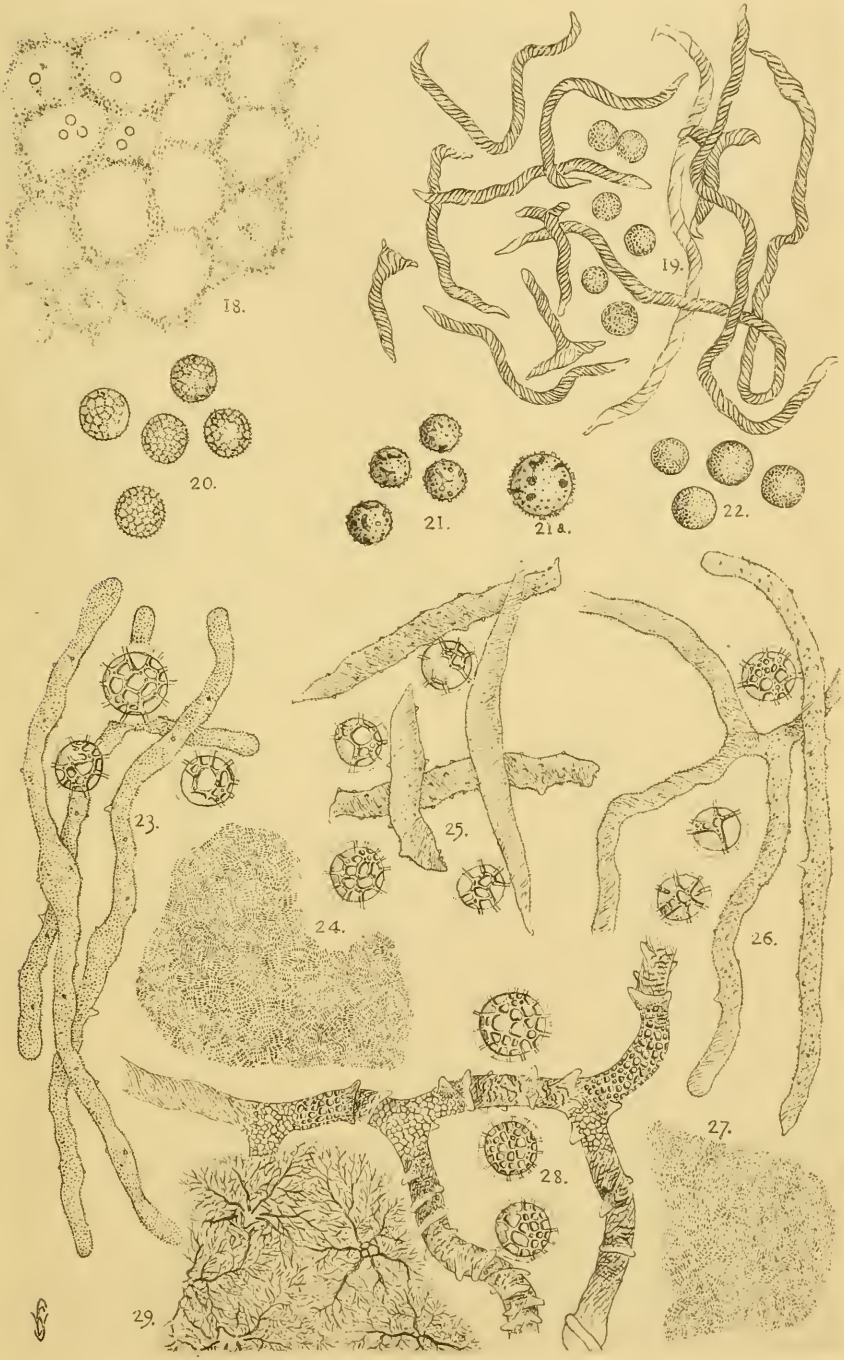
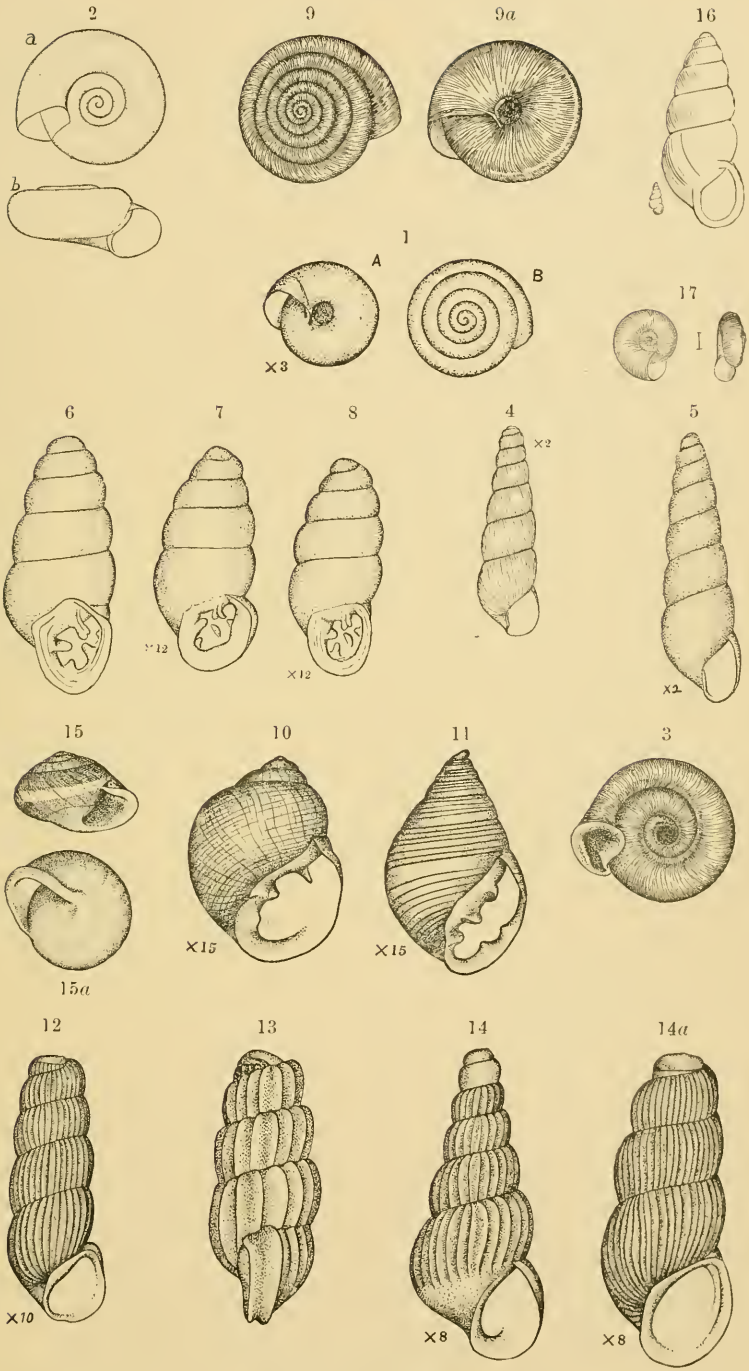
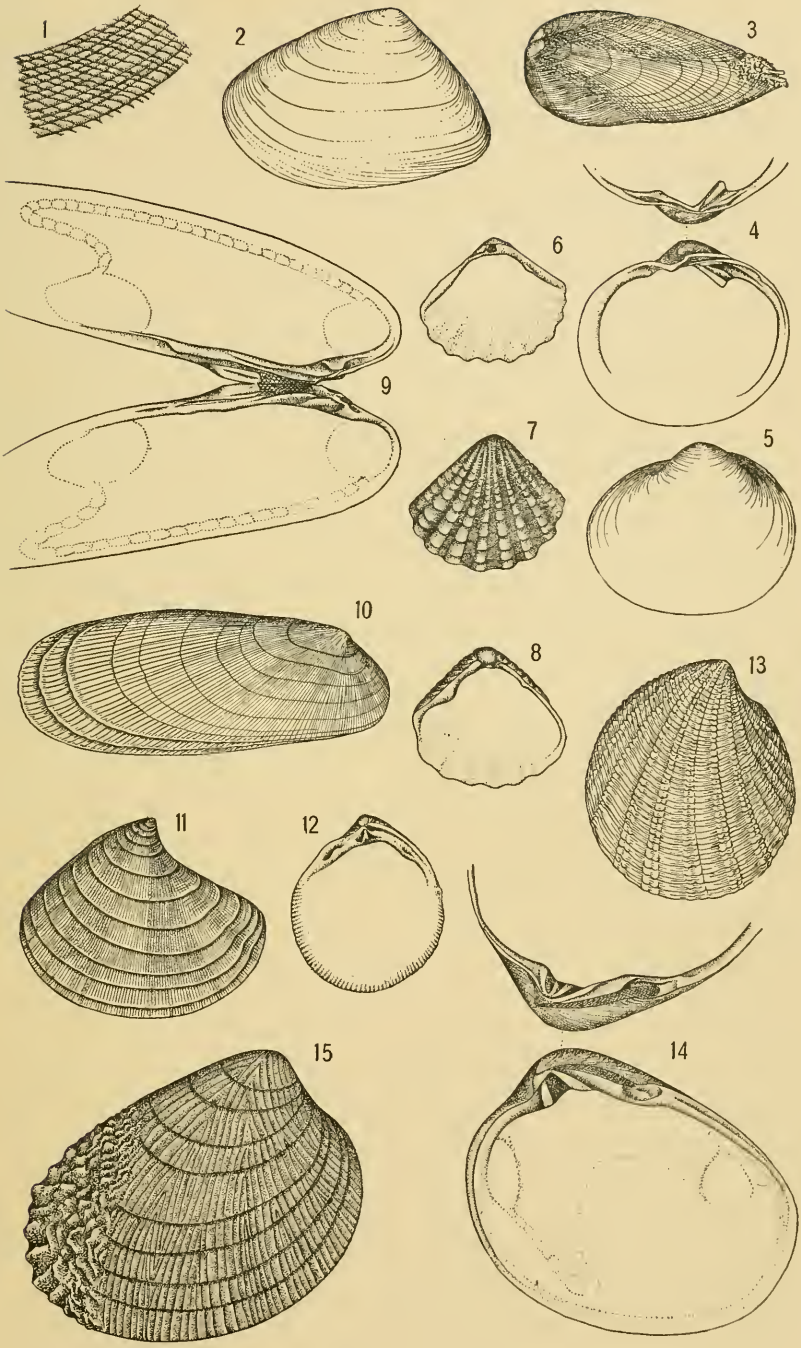


Heliotype Co, Boston

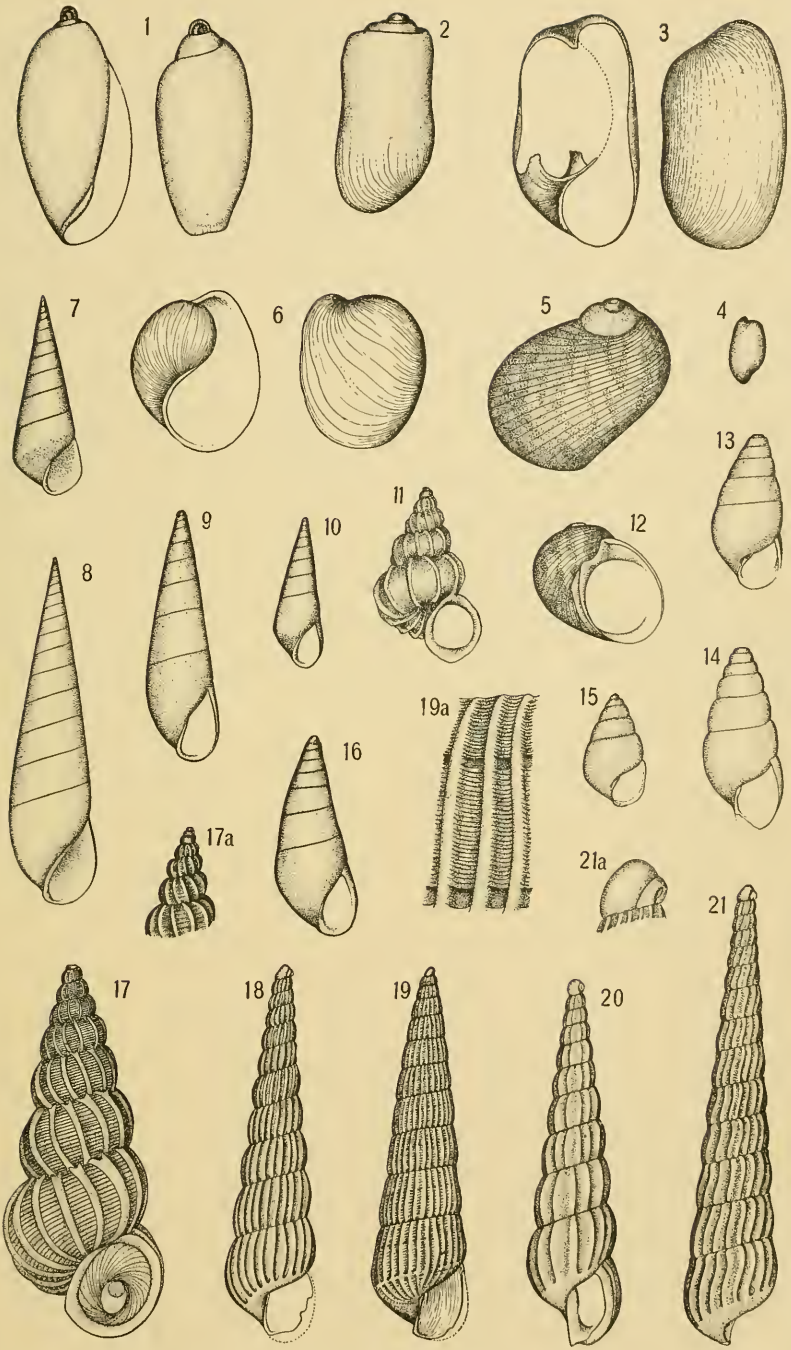


Bermuda Land Shells.



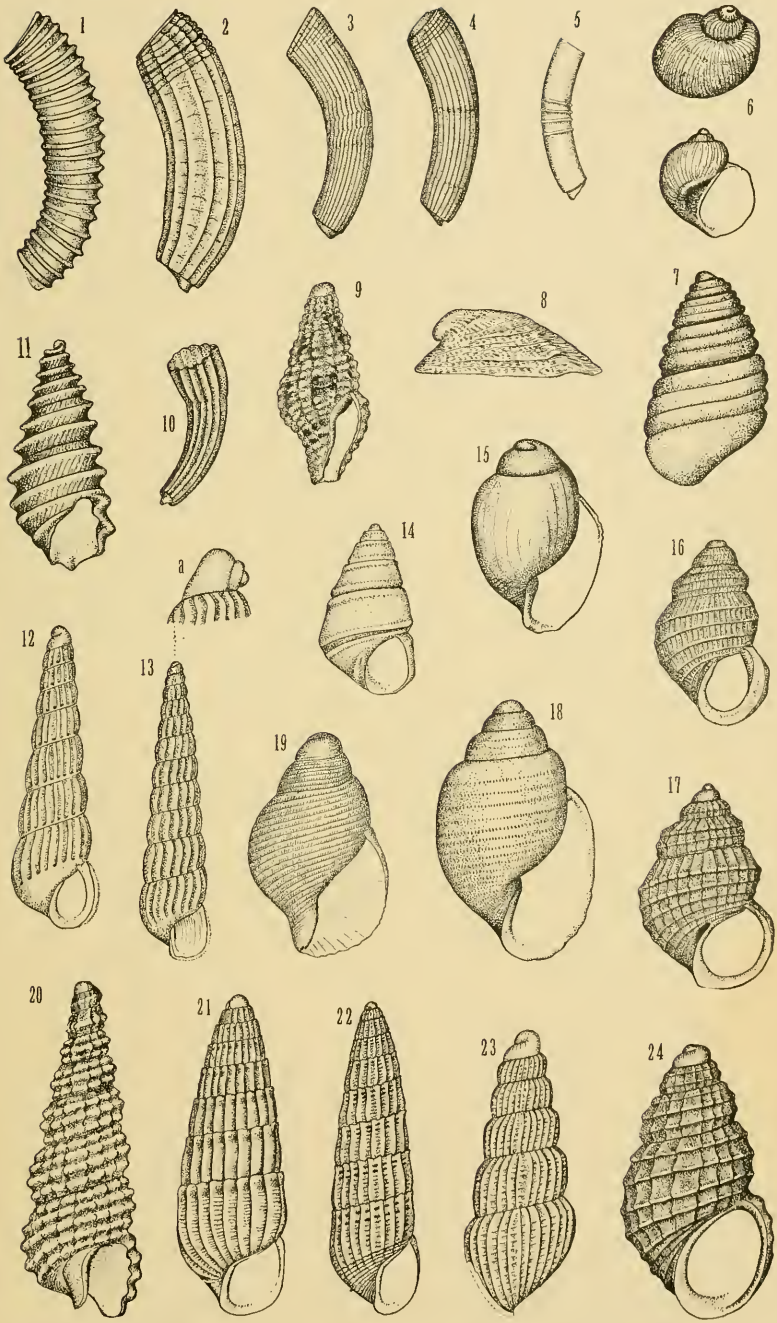
A. Hyatt Verrill from nature.

BERMUDA MARINE SHELLS.



A. Hyatt Verrill from nature.

BERMUDA MARINE SHELLS.



A. Hyatt Verrill from nature.

BERMUDA MARINE SHELLS.

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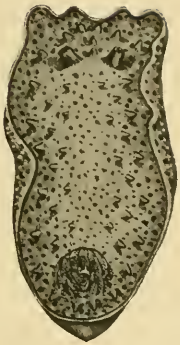

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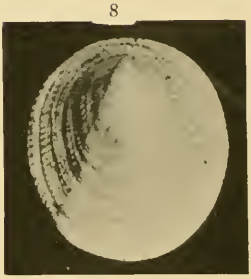

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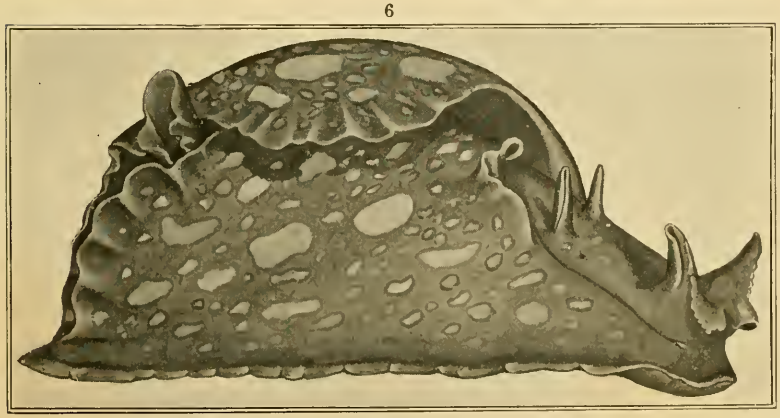
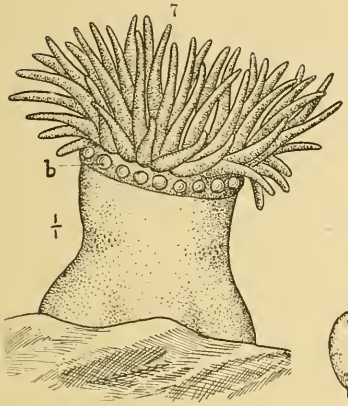
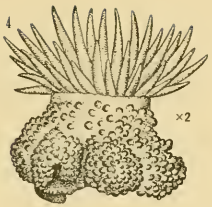
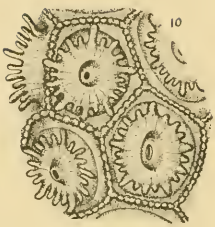
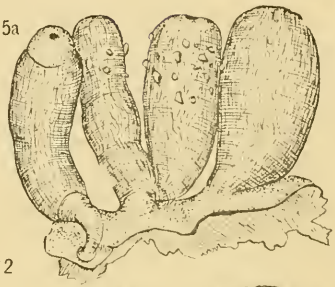


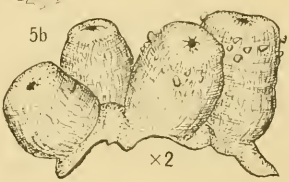
A. Hyatt Verrill from nature.

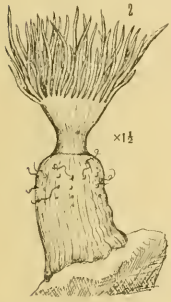


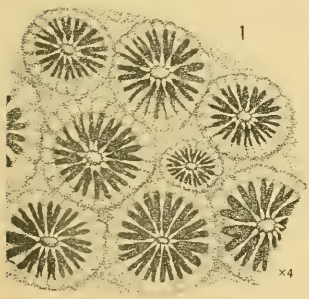


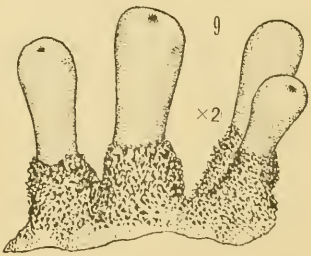


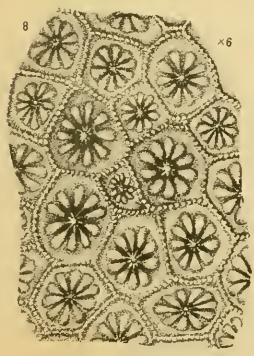












A. Hyatt Verrill from nature.

BERMUDA ANTHOZOA.

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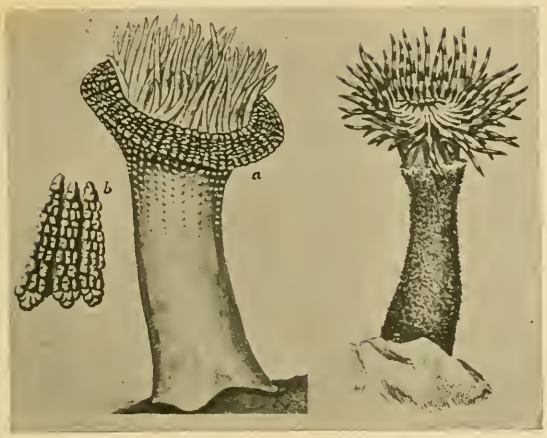

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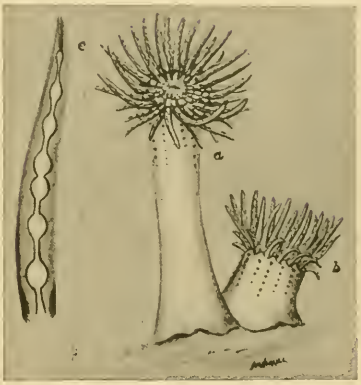

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A. Hyatt Verrill from nature.

BERMUDA ANTHOZOA.

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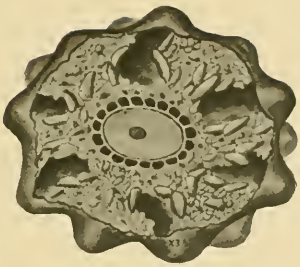

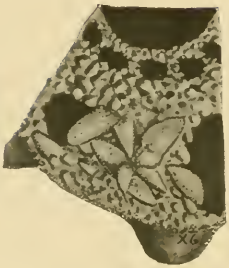

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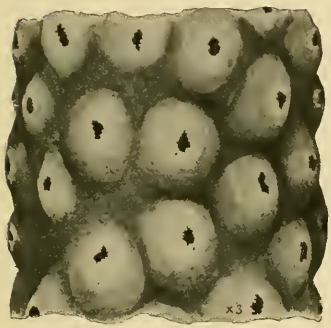

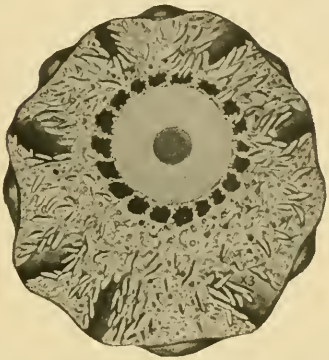

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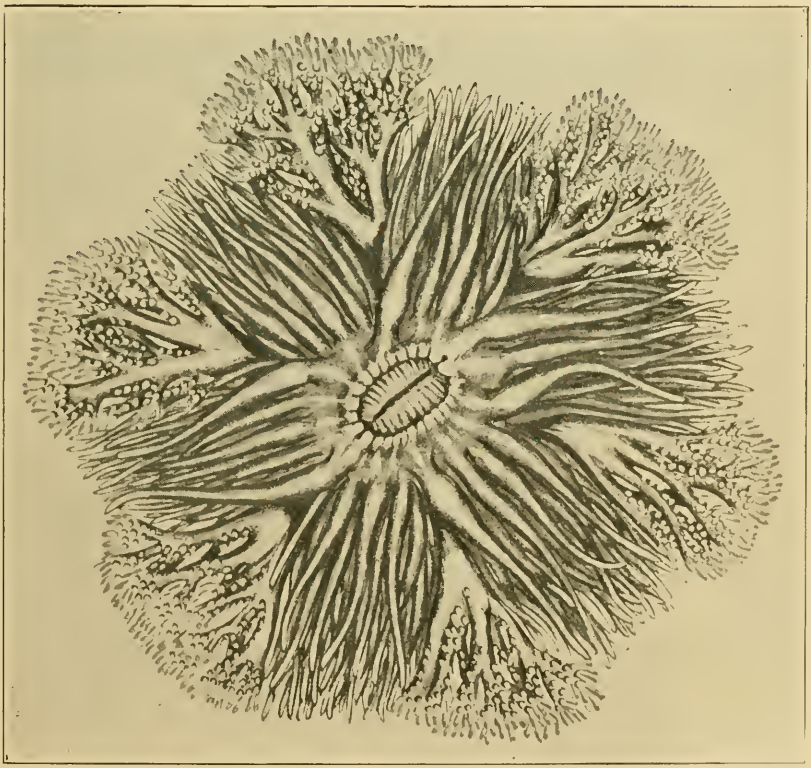

A. Hyatt Verrill from nature.

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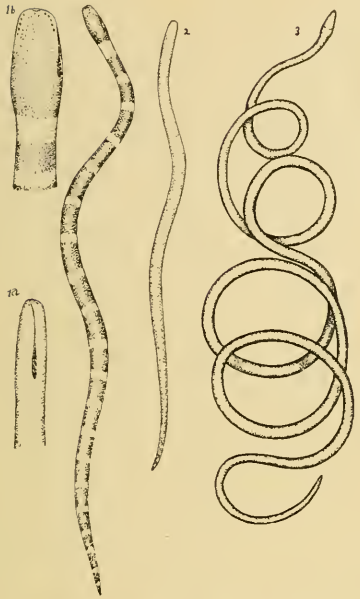

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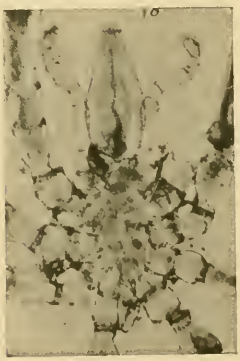

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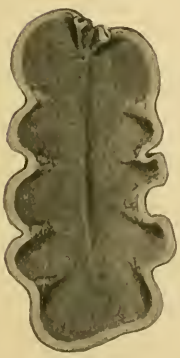

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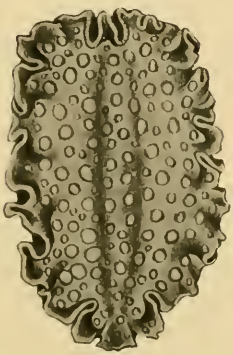

6a

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